Construction Documents – 100% CD Submittal: Specifications

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Electronic Health Record Modernization (EHRM) Infrastructure Upgrades – Togus, ME

Project No. 402-22-700

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Togus VA Medical Center

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SECTION 21 08 00

COMMISSIONING OF FIRE SUPPRESSION SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. The requirements of this Section apply to all sections of Division 21.

B. This project will have selected building systems commissioned. The complete list of equipment and systems to be commissioned is specified in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS. The commissioning process, which the Contractor is responsible to execute, is defined in Section 01 91 00 GENERAL COMMISSIONING REQUIRMENTS. A Commissioning Agent (CxA) hired by the Contractor will manage the commissioning process.

1.2 RELATED WORK

A. Section 01 00 00 GENERAL REQUIREMENTS.

B. Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS.

C. Section 01 33 23 SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

D. Section 21 13 13 WET-PIPE SPRINKLER SYSTEMS

E. Section 21 22 00 CLEAN AGENT FIRE SUPPRESSION SYSTEMS

F. Section 28 31 00 FIRE DETECTION AND ALARM

1.3 SUMMARY

A. This Section includes requirements for commissioning the Fire Suppression systems, subsystems and equipment. This Section supplements the general requirements specified in Section 01 91 00 General Commissioning Requirements.

B. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for more details regarding processes and procedures as well as roles and responsibilities for all Commissioning Team members.

1.4 DEFINITIONS

A. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for definitions.

1.5 COMMISSIONED SYSTEMS

A. Commissioning of a system or systems specified in Division 21 is part of the construction process. Documentation and testing of these systems, as well as training of the VA’s Operation and Maintenance personnel in accordance with the requirements of Section 01 91 00 and of Division 21, is required in cooperation with the VA and the Commissioning Agent.

B. The Fire Suppression systems commissioning will include the following systems:

1. New fire sprinkler system for the New Main Computer Room building.
2. New clean agent suppression system for the new Main Computer Room building.

1.6 SUBMITTALS

A. The commissioning process requires review of selected Submittals. The Commissioning Agent will provide a list of submittals that will be reviewed by the Commissioning Agent. This list will be reviewed and approved by the VA prior to forwarding to the Contractor. Refer to Section 01 33 23 SHOP DRAWINGS, PRODUCT DATA, and SAMPLES for further details.

B. The commissioning process requires Submittal review simultaneously with engineering review. Specific submittal requirements related to the commissioning process are specified in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 CONSTRUCTION INSPECTIONS

A. Commissioning of the building fire suppression systems will require inspection of individual elements of the fire suppression construction throughout the construction period. The Contractor shall coordinate with the Commissioning Agent in accordance with Section 01 91 00 and the Commissioning plan to schedule inspections as required to support the Commissioning Process.

3.2 PRE-FUNCTIONAL CHECKLISTS

A. The Contractor shall complete Pre-Functional Checklists to verify systems, subsystems, and equipment installation is complete and systems are ready for Systems Functional Performance Testing. The Commissioning Agent will prepare Pre-Functional Checklists to be used to document equipment installation. The Contractor shall complete the checklists. Completed checklists shall be submitted to the VA and to the Commissioning Agent for review. The Commissioning Agent may spot check a sample of completed checklists. If the Commissioning Agent determines that the information provided on the checklist is not accurate, the Commissioning Agent will return the marked-up checklist

to the Contractor for correction and resubmission. If the Commissioning Agent determines that a significant number of completed checklists for similar equipment are not accurate, the Commissioning Agent will select a broader sample of checklists for review. If the Commissioning Agent determines that a significant number of the broader sample of checklists is also inaccurate, all the checklists for the type of equipment will be returned to the Contractor for correction and resubmission. Refer to SECTION 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for submittal requirements for Pre-Functional Checklists, Equipment Startup Reports, and other commissioning documents.

3.3 CONTRACTORS TESTS

A. Contractor tests as required by other sections of Division 21 shall be scheduled and documented in accordance with Section 01 00 00 GENERAL REQUIREMENTS. All testing shall be incorporated into the project schedule. Contractor shall provide no less than 7 calendar days' notice of testing. The Commissioning Agent will witness selected Contractor tests at the sole discretion of the Commissioning Agent. Contractor tests shall be completed prior to scheduling Systems Functional Performance Testing.

3.4 SYSTEMS FUNCTIONAL PERFORMANCE TESTING

A. The Commissioning Process includes Systems Functional Performance Testing that is intended to test systems functional performance under steady state conditions, to test system reaction to changes in operating conditions, and system performance under emergency conditions. The Commissioning Agent will prepare detailed Systems Functional Performance Test procedures for review and approval by the COR. The Contractor shall review and comment on the tests prior to approval. The Contractor shall provide the required labor, materials, and test equipment identified in the test procedure to perform the tests. The Commissioning Agent will witness and document the testing. The Contractor shall sign the test reports to verify tests were performed. See Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS, for additional details.

3.5 TRAINING OF VA PERSONNEL

A. Training of the VA operation and maintenance personnel is required in cooperation with the COR and Commissioning Agent. Provide competent, factory authorized personnel to provide instruction to operation and

maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. Contractor shall submit training agendas and trainer resumes in accordance with the requirements of Section 01 91 00. The instruction shall be scheduled in coordination with the COR after submission and approval of formal training plans. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS and Division 21 Sections for additional Contractor training requirements.

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SECTION 21 13 13
WET-PIPE SPRINKLER SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Design, installation and testing shall be in accordance with NFPA 13-2022.

B. Modification of the existing sprinkler system as indicated on the drawings and as further required by these specifications. The scope of work includes adjusting existing sprinkler and piping layout for all Telecommunication Room and Telecommunication Enclosure locations, as well as the design and installation of a hydraulically calculated automatic wet-pipe system complete and ready for operation for the new Main Computer Room building.

C. Telecommunication rooms (TR) will require modifications to the existing building sprinkler system to provide coverage as required by NFPA 13. The contractor shall provide new sprinkler heads and mechanical guards for all Telecommunication Rooms and Telecommunication Enclosures.

D. Contractor shall shut off the appropriate sprinkler system zone valve, drain the water in the piping in that zone, relocate the indicated heads, flush the piping in the affected zone, and recharge the zone. Contact the campus fire department prior to shutting down any system or system zone.

G. It is not permissible to mix quick response and standard response sprinklers. Sprinklers within the same compartment shall have the same response characteristics.

H. Sprinkler systems protecting the Data Center Room 111 and Entrance Room A 100 and Entrance Room B 112 will be valved separately from other sprinkler systems as required by NFPA 75. The valve is required to be supervised by the building fire alarm system and provided in an accessible location.

I. For Data Center Room 11, where aisle containment is provided, sprinklers shall be installed within the containment. If UL-listed thermal-drop panels are used, omission of sprinklers shall be permitted.

1.2 RELATED WORK

A. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Section 33 10 00, WATER UTILITIES.

C. Section 07 84 00, FIRESTOPPING.

D. Section 09 91 24, INTERIOR PAINTING.

E. Section 21 08 00, COMMISSIONING OF FIRE SUPPRESSION SYSTEMS

F. Section 21 13 45, SPRINKLER GUARDS.

G. Section 28 31 00, FIRE DETECTION AND ALARM.

1.3 DESIGN CRITERIA

A. Design Basis Information: Provide design, materials, equipment, installation, inspection, and testing of the automatic sprinkler system in accordance with the requirements of NFPA 13.

1. Perform hydraulic calculations in accordance with NFPA 13 utilizing the Area/Density method. Do not restrict design area reductions permitted for using quick response sprinklers throughout by the required use of standard response sprinklers in the areas identified in this section.
2. Sprinkler Protection: Sprinkler hazard classifications shall be in accordance with NFPA 13. The hazard classification examples of uses and conditions identified in the Annex of NFPA 13 shall be mandatory for areas not listed below. Request clarification from the Government for any hazard classification not identified. To determining spacing and sizing, apply the following coverage classifications:
   a. Light Hazard Occupancies: Telecommunication rooms, offices, customary access areas.
   b. Ordinary Hazard Group 1 Occupancies: Telecommunication spaces, Mechanical Equipment Rooms, Transformer Rooms, Electrical Switchgear Rooms, Electric Closets, and Repair Shops.
   c. Ordinary Hazard Group 2 Occupancies: Storage rooms, trash rooms, storage areas, building management storage, energy centers, warehouse spaces.
3. Hydraulic Calculations: Calculated demand including hose stream requirements shall fall no less than 10 percent below the available water supply curve.
4. Water Supply: Contractor required to perform flow test confirming adequate water supply within 12 months of submitting fire sprinkler

shop drawings. Flow test to be conducted by the contractor and coordinated with the Togus Fire Department. Contractor to conduct the final flow test after all new mains have been installed for the project. Preliminary flow test information provided below is for preliminary design information only:

a. Location Test Hydrant: North side of Bldg 209, Hydrant #3
b. Location Flow Hydrant: Hill North Side 200, Hydrant #2
c. Elevation Static Test Gauge: 168 ft
d. Elevation Residual Test Gauge: 169 ft
e. Static pressure: 65 psi
f. Residual pressure: 58 psi
g. Flow: 1,113 gpm
h. Date: 11/06/2017
i. Time: unknown

5. Zoning:
   a. For each sprinkler zone provide a control valve, flow switch, and a test and drain assembly with pressure gauge.
   b. The Data Center Room 111 and Entrance Room A 100 and Entrance Room B 112 shall be provided a separate control valve from the remaining MCR.
6. Provide seismic protection in accordance with NFPA 13. Contractor shall submit load calculations for sizing of sway bracing for systems that are required to be protected against damage from earthquakes. Seismicity of this location is Moderate Low in accordance with VA Seismic Risk Definitions, July 1, 2023. Spectral response acceleration parameters: S_s = 0.31, S_1 = 0.068. Identify seismic protection on the fire sprinkler shop drawings.

1.4 SUBMITTALS

A. Submit as one package in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES. Prepare detailed working drawings that are signed by a NICET Level III or Level IV Sprinkler Technician or stamped by a Registered Professional Engineer licensed in the field of Fire Protection Engineering. As the Government review is for technical adequacy only, the installer remains responsible for correcting any conflicts with other trades and building construction

that arise during installation. Partial submittals will not be accepted. Material submittals shall be approved prior to the purchase or delivery to the job site. Suitably bind submittals in notebooks or binders and provide an index referencing the appropriate specification section. In addition to the hard copies, provide submittal items in Paragraphs 1.4(A)1 through 1.4(A)5 electronically in pdf format on a compact disc or as directed by the COR. Submittals shall include, but not be limited to, the following:

1. Qualifications:
   a. Provide a copy of the installing state contractor's license.
   b. Provide a copy of the NICET certification for the NICET Level III or Level IV Sprinkler Technician who prepared and signed the detailed working drawings unless the drawings are stamped by a Registered Professional Engineer licensed in the field of Fire Protection Engineering.
   c. Provide documentation showing that the installer has been actively and successfully engaged in the installation of commercial automatic sprinkler systems for the past ten years.
2. Drawings: Submit detailed 1:100 (1/8 inch) scale (minimum) working drawings conforming to the Plans and Calculations chapter of NFPA 13. Drawings shall include graphical scales that allow the user to determine lengths when the drawings are reduced in size. Include a plan showing the piping to the water supply test location.
3. Manufacturer's Data Sheets: Provide data sheets for all materials and equipment proposed for use on the system. Include listing information and installation instructions in data sheets. Where data sheets describe items in addition to those proposed to be used for the system, clearly identify the proposed items on the sheet.
4. Calculation Sheets:
   a. Submit hydraulic calculation sheets in tabular form conforming to the requirements and recommendations of the Plans and Calculations chapter of NFPA 13.
   b. Submit calculations of loads for sizing of sway bracing in accordance with NFPA 13.
5. Final Document Submittals: Provide as-built drawings, testing and maintenance instructions in accordance with the requirements in

Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES. In addition, submittals shall include, but not be limited to, the following:

a. A complete set of as-built drawings showing the installed system with the specific interconnections between the system switches and the fire alarm equipment. Provide a complete set in the formats as follows. Submit items 2 and 3 below on a compact disc or as directed by the COR.
   1) One full size (or size as directed by the COR) printed copy.
   2) One complete set in electronic pdf format.
   3) One complete set in AutoCAD format or a format as directed by the COR.
b. Material and Testing Certificate: Upon completion of the sprinkler system installation or any partial section of the system, including testing and flushing, provide a copy of a completed Material and Testing Certificate as indicated in NFPA 13. Certificates shall be provided to document all parts of the installation.
c. Operations and Maintenance Manuals that include step-by-step procedures required for system startup, operation, shutdown, and routine maintenance and testing. The manuals shall include the manufacturer's name, model number, parts list, 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.
d. One paper copy of the Material and Testing Certificates and the Operations and Maintenance Manuals above shall be provided in a binder. In addition, these materials shall be provided in pdf format on a compact disc or as directed by the COR.
e. Provide one additional copy of the Operations and Maintenance Manual covering the system in a flexible protective cover and mount in an accessible location adjacent to the riser or as directed by the COR.

1.5 QUALITY ASSURANCE

A. Installer Reliability: The installer shall possess a valid State of Maine fire sprinkler contractor's license. The installer shall have been actively and successfully engaged in the installation of commercial automatic sprinkler systems for the past ten years.

B. Materials and Equipment: All equipment and devices shall be of a make and type listed by UL or approved by FM, or other nationally recognized testing laboratory for the specific purpose for which it is used. All materials, devices, and equipment shall be approved by the VA. All materials and equipment shall be free from defect. All materials and equipment shall be new unless specifically indicated otherwise on the contract drawings.

1.6 APPLICABLE PUBLICATIONS

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

B. National Fire Protection Association (NFPA):

13-2022.....Installation of Sprinkler Systems

25-2020.....Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems

75-2020.....Fire Protection of Information Technology Equipment

101-2021.....Life Safety Code

170-2021.....Fire Safety and Emergency Symbols

C. Underwriters Laboratories, Inc. (UL):

Fire Protection Equipment Directory

D. Factory Mutual Engineering Corporation (FM):

Approval Guide

PART 2 - PRODUCTS

2.1 PIPING & FITTINGS

A. Piping and fittings for private underground water mains shall be in accordance with NFPA 13.

1. Pipe and fittings from inside face of building 300 mm (12 in.) above finished floor to a distance of approximately 1500 mm (5 ft.) outside building: Ductile Iron, flanged fittings and 316 stainless steel bolting.

B. Piping and fittings for sprinkler systems shall be in accordance with NFPA 13.
   1. Plain-end pipe fittings with locking lugs or shear bolts are not permitted.
   2. Piping sizes 50 mm (2 inches) and smaller shall be black steel Schedule 40 with threaded end connections.
   3. Piping sizes 65 mm (2 ½ inches) and larger shall be black steel Schedule 10 with grooved connections. Grooves in Schedule 10 piping shall be rolled grooved only.
   4. Use nonferrous piping in MRI Scanning Rooms.
   5. Plastic piping shall not be permitted except for drain piping.
   6. Flexible sprinkler hose shall be FM Approved and limited to hose with threaded end fittings with a minimum inside diameter or 1-inch and a maximum length of 6-feet.

2.2 VALVES

A. General:
   1. Valves shall be in accordance with NFPA 13.
   2. Do not use quarter turn ball valves for 50 mm (2 inch) or larger drain valves.

B. Control Valve: The control valves shall be a listed indicating type. Control valves shall be UL Listed or FM Approved for fire protection installations. System control valve shall be rated for normal system pressure but in no case less than 175 PSI.

C. Check Valve: Shall be of the swing type with a flanged cast iron body and flanged inspection plate.

D. Automatic Ball Drips: Cast brass 20 mm (3/4 inch) in-line automatic ball drip with both ends threaded with iron pipe threads.

E. Backflow Preventer: Provide backflow preventer for the MCR system. Provide means to forward flow test the backflow preventer in accordance with NFPA 13.

F. Vertical Indicator Posts: Provide a UL-Listed/FM-Approved adjustable vertical indicator post for the new gate valve on the water service line. The indicator post shall be compatible with the non-rising stem gate valve (PIV). The post shall feature a factory-applied red epoxy coating, and include a telescoping stem adjustable to final grade without field cutting. The post shall include integral “OPEN” and

"SHUT" target plates and a mounting provision for a supervisory switch. Provide and install a UL/FM-listed supervisory switch for valve position monitoring in accordance with NFPA 72.

2.3 FIRE DEPARTMENT SIAMESE CONNECTION

A. Brass, flush wall type, exterior fire department connection with brass escutcheon plate, and a minimum of two 65 mm (2-1/2 inch) connections threaded to match those on the local fire protection service, with polished brass caps and chains. Provide escutcheon with integral raised letters "Automatic Sprinkler". Install an automatic ball drip between fire department connection and check valve with drain piping routed to the exterior of the building or a floor drain.

2.4 SPRINKLERS

A. All sprinklers shall be FM approved.

B. All sprinklers shall be quick response except identified as follows.

C. For Telecommunication Rooms, Telecommunication Enclosures, Entrance Rooms, and Electrical rooms: use standard-response, fusible-link sprinklers, with mechanical guards UL listed for the installed sprinkler model.

D. Data Center (Room 111): use standard-response, fusible-link sprinklers, with mechanical guards UL listed for the installed sprinkler model.

E. Other occupied spaces with ceilings: provide white, quick-response sprinklers.

F. Other spaces without ceilings: provide brass, quick-response upright sprinklers.

B. Temperature Ratings: In accordance with NFPA 13 except that sprinklers in elevator shafts and elevator machine rooms shall be no less than intermediate temperature rated and sprinklers in generator rooms shall be no less than high temperature rated. Provide intermediate temperature sprinklers in all mechanical, electrical, telecommunication rooms, data center, and entrance rooms, and elsewhere as required by

NFPA 13. Use higher-temperature sprinklers where dictated by ambient conditions or NFPA 13 criteria.

2.5 SPRINKLER CABINET

A. Provide sprinkler cabinet with the required number of sprinkler heads of all ratings and types installed, and a sprinkler wrench for each type of sprinkler in accordance with NFPA 13. Locate adjacent to the riser.

B. Provide a list of sprinklers installed in the property in the cabinet. The list shall include the following:

1. Manufacturer, model, orifice, deflector type, thermal sensitivity, and pressure for each type of sprinkler in the cabinet.
2. General description of where each sprinkler is used.
3. Quantity of each type present in the cabinet.
4. Issue or revision date of list.

2.6 SPRINKLER SYSTEM SIGNAGE

A. Rigid plastic, steel or aluminum signs with white lettering on a red background with holes for easy attachment. Sprinkler system signage shall be attached to the valve or piping with chain.

2.7 SWITCHES:

A. OS&Y Valve Supervisory Switches shall be in a weatherproof die cast/red baked enamel, oil resistant, aluminum housing with tamper resistant screws, 13 mm (1/2 inch) conduit entrance and necessary facilities for attachment to the valves. Provide two SPDT switches rated at 2.5 amps at 24 VDC.

B. Water flow Alarm Switches: Mechanical, non-coded, non-accumulative retard and adjustable from 0 to 60 seconds minimum. Set flow switches at an initial setting between 20 and 30 seconds.

D. Valve Supervisory Switches for Ball and Butterfly Valves: May be integral with the valve.

2.8 GAUGES

A. Provide gauges as required by NFPA 13. Provide gauges where the normal pressure of the system is at the midrange of the gauge.

B. Provide pressure gauges upstream and downstream of the backflow preventer, at each flow switch, and on each test/drain per NFPA 13.

2.9 PIPE HANGERS, SUPPORTS AND RESTRAINT OF SYSTEM PIPING

A. Pipe hangers, supports, and restraint of system piping shall be in accordance with NFPA 13.

2.10 WALL, FLOOR AND CEILING PLATES

A. Provide chrome plated steel escutcheon plates.

2.11 ANTIFREEZE SOLUTION – NOT USED

2.12 VALVE TAGS

A. Engraved black filled numbers and letters not less than 15 mm (1/2 inch) high for number designation, and not less than 8 mm (1/4 inch) for service designation on 19 gage, 40 mm (1-1/2 inches) round brass disc, attached with brass "S" hook, brass chain, or nylon twist tie.

2.13 AIR VENT

A. Provide air vent for fire system zone protecting the MCR.

B. Air vents shall be UL or FM approved.

C. Air vent shall be located near the high-point of the system.

D. Air vent shall be one of the following methods:

1. Manual Valve, minimum 1/2 in.
2. Automatic air vent.
3. Remote inspector’s test valve.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation shall be accomplished by the licensed contractor. Provide a qualified technician, experienced in the installation and operation of the type of system being installed, to supervise the installation and testing of the system.

B. Installation of Piping: Accurately cut pipe to measurements established by the installer and work into place without springing or forcing. In any situation where bending of the pipe is required, use a standard pipe-bending template. Concealed piping in spaces that have finished ceilings. Where ceiling mounted equipment exists, such as in operating and radiology rooms, install sprinklers so as not to obstruct the movement or operation of the equipment. Sidewall heads may need to be utilized. In stairways, locate piping as near to the ceiling as possible to prevent tampering by unauthorized personnel and to provide a minimum headroom clearance of 2250 mm (seven feet six inches). Piping shall not obstruct the minimum means of egress clearances required by

NFPA 101. Pipe hangers, supports, and restraint of system piping, and seismic bracing shall be installed accordance with NFPA 13.

C. Welding: Conform to the requirements and recommendations of NFPA 13.

D. Drains: Provide drips and drains, including low point drains, in accordance with NFPA 13. Pipe drains to discharge at safe points outside of the building or to sight cones attached to drains of adequate size to readily carry the full flow from each drain under maximum pressure. Do not provide a direct drain connection to sewer system or discharge into sinks. Install drips and drains where necessary and required by NFPA 13. The drain piping shall not be restricted or reduced and shall be of the same diameter as the drain collector.

E. Supervisory Switches: Provide supervisory switches for sprinkler control valves.

F. Waterflow Alarm Switches: Install waterflow alarm switches and valves in stairwells or other easily accessible locations.

G. Inspector's Test Connection: Install and supply in accordance with NFPA 13, locate in a secured area, and discharge to the exterior of the building.

H. Affix cutout disks, which are created by cutting holes in the walls of pipe for flow switches and non-threaded pipe connections to the respective waterflow switch or pipe connection near to the pipe from where they were cut.

I. Provide escutcheon plates for exposed piping passing through walls, floors or ceilings.

J. Clearances: For systems requiring seismic protection, piping that passes through floors or walls shall have penetrations sized 50 mm (2 inches) nominally larger than the penetrating pipe for pipe sizes 25 mm (1 inch) to 90 mm (3 ½ inches) and 100 mm (4 inches) nominally larger for penetrating pipe sizes 100 mm (4 inches) and larger.

K. Sleeves: Provide for pipes passing through masonry or concrete. Provide space between the pipe and the sleeve in accordance with NFPA 13. Seal this space with a UL Listed through penetration fire stop material in accordance with Section 07 84 00, FIRESTOPPING. Where core drilling is used in lieu of sleeves, also seal space. Seal penetrations of walls,

floors and ceilings of other types of construction, in accordance with Section 07 84 00, FIRESTOPPING.

L. Where dry pendent sprinklers are used for freezers or similar spaces and they are connected to the wet pipe system, provide an EPDM boot around the dry pendent sprinkler on the heated side and securely seal to the pipe and freezer to prevent condensation from entering the freezer.

M. Provide pressure gauges at each water flow alarm switch location and at each main drain connection.

N. For each fire department connection, provide the symbolic sign given in NFPA 170 and locate 2400 to 3000 mm (8 to 10 feet) above each connection location. Size the sign to 450 by 450 mm (18 by 18 inches) with the symbol being at least 350 by 350 mm (14 by 14 inches).

O. Firestopping shall be provided for all penetrations of fire resistance rated construction. Firestopping shall comply with Section 07 84 00, FIRESTOPPING.

P. Painting of Pipe: All new exposed fire sprinkler piping, and any existing sprinkler piping exposed as a result of this project, shall be painted with two coats of gloss red enamel. Paint all valves and operating accessories with two coats of gloss red enamel as well. Concealed piping located above suspended ceilings or within crawl spaces does not require painting. Painting of sprinkler systems above ceilings and in concealed spaces is not required. Painting shall comply with Section 09 91 24 – INTERIOR PAINTING. Exercise care to avoid getting paint on sprinklers. Any sprinkler that becomes painted shall be replaced with a new sprinkler.

Q. Sprinkler System Signage: Provide rigid sprinkler system signage in accordance with NFPA 13 and NFPA 25. Sprinkler system signage shall include, but not limited to, the following:

1. Identification Signs:
   a. Provide signage for each control valve, drain valve, sprinkler cabinet, and inspector’s test.
   b. Provide valve tags for each operable valve. Coordinate nomenclature and identification of operable valves with COR. Where existing nomenclature does not exist, the Tag Identification shall include no less than the following: (FP-B-

F/SZ-#) Fire Protection, Building Number, Floor Number/Smoke Zone (if applicable), and Valve Number. (E.g., FP-500-1E-001) Fire Protection, Building 500, First Floor East, Number 001.)

2. Instruction/Information Signs:
   a. Provide signage for each control valve to indicate valve function and to indicate what system is being controlled.
   b. Provide signage indicating the number and location of low point drains.
3. Hydraulic Placards:
   a. Provide signage indicating hydraulic design information. The placard shall include location of the design area, discharge densities, required flow and residual pressure at the base of riser, occupancy classification, hose stream allowance, flow test information, and installing contractor. Locate hydraulic placard information signs at each alarm check valve.

R. Repairs: Repair damage to the building or equipment resulting from the installation of the sprinkler system by the installer at no additional expense to the Government.

S. Interruption of Service: There shall be no interruption of the existing sprinkler protection, water, electric, or fire alarm services without prior permission of the Contracting Officer. Contractor shall develop an interim fire protection program where interruptions involve occupied spaces. Request in writing at least one week prior to the planned interruption.

3.2 INSPECTION AND TEST

A. Preliminary Testing: Flush newly installed systems prior to performing hydrostatic tests in order to remove any debris which may have been left as well as ensuring piping is unobstructed. Hydrostatically test system, including the fire department connections, as specified in NFPA 13, in the presence of the Contracting Officers Representative (COR) or his designated representative. Test and flush underground water line prior to performing these hydrostatic tests.

B. Final Inspection and Testing: Subject system to tests in accordance with NFPA 13, and when all necessary corrections have been accomplished, advise COR to schedule a final inspection and test.

Connection to the fire alarm system shall have been in service for at least ten days prior to the final inspection, with adjustments made to prevent false alarms. Furnish all instruments, labor and materials required for the tests and provide the services of the installation foreman or other competent representative of the installer to perform the tests. Correct deficiencies and retest system as necessary, prior to the final acceptance. Include the operation of all features of the systems under normal operations in test.

C. Submit documentation for the following tests:

a. Underground Piping:

i. Perform hydrostatic pressure test and flushing of the underground fire service main prior to connection to the building system.

ii. Testing shall comply with NFPA 24.

iii. Document results using the NFPA 24 Contractor’s Material and Test Certificate for Underground Piping.

b. Aboveground Sprinkler System:

i. Perform hydrostatic pressure test of the fire sprinkler system per NFPA 13.

ii. Submit results using the NFPA 13 Contractor’s Material and Test Certificate for Aboveground Piping (form attached if the contractor does not have their own).

c. Back Flow Preventer:

i. Conduct a forward flow test of the fire protection backflow preventer assembly in accordance with NFPA 25 (2019), Section 13.7.2 and local water authority requirements.

ii. Test shall verify that flow through the assembly equals or exceeds the system demand, including hose allowance.

iii. Record and submit results as part of the final closeout documentation.

3.3 INSTRUCTIONS

Furnish the services of a competent instructor for not less than two hours for instructing personnel in the operation and maintenance of the system, on the dates requested by the COR.

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SECTION 21 13 45
SPRINKLER GUARDS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Supply and installation of sprinkler guards for new and existing wet-pipe system sprinklers in all Telecommunication Rooms (TR), all Telecommunication Enclosure (TE) Rooms, Data Center Room 111, Entrance Rooms A 100, Entrance Room B 112, and Electrical Room 105.

B. The sprinkler guard shall be UL listed for use with the make and model of the sprinkler being protected.

1.2 RELATED WORK

A. Section 02 41 00, DEMOLITION OF EXISTING CEILING SYSTEMS.

B. Section 21 13 13, WET-PIPE SPRINKLER SYSTEMS

1.3 DESIGN CRITERIA

A. UL Listed, Hard-wire cage designed to encase the sprinkler and protect it from mechanical damage. Guards shall be approved by the manufacturer for use with upright or pendent style sprinklers.

1.4 SUBMITTALS

A. Submit as one package in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

1. Manufacturers technical data
2. Two samples of each proposed type

1.5 QUALITY ASSURANCE

A. Listings and Approvals

1. UL listed
2. FM approved class 2901

1.6 APPLICABLE PUBLICATIONS

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

B. National Fire Protection Association (NFPA):
13-2022 Standard for the Installation of Sprinkler Systems

C. Underwriters Laboratories, Inc. (UL):
Fire Protection Equipment Directory (2011)

D. Factory Mutual Engineering Corporation (FM):
Approval Guide

PART 2 - PRODUCTS

2.1 PIPING & FITTINGS

A. Basis of Design

1. The sprinkler guard shall be listed for use with the make and model of the sprinkler being protected.
2. Viking model D-1 Sprinkler guard
   The Viking Corporation, 2010 N Industrial Park Drive, Hastings, MI 49058. Telephone: 269-945-9501 Technical Services: 877-384-5494 Fax:269-818-1680 Email:techsvcs@vikingcorp.com
   www.vikinggroupinc.com
3. Or approved equal.

2.2 SPARES

A. Provide four (4) spare guards of each type

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation shall be accomplished by a qualified technician, experienced in the installation of sprinkler guards.

B. Repairs: Repair damage to the building or equipment resulting from the installation of the sprinkler guards by the installer at no additional expense to the Government.

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SECTION 21 22 00

CLEAN AGENT FIRE SUPPRESSION SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Data Center Room 111 in the new Main Computer Room Building is a telecommunication space (TS) designated with ANSI/TIA-942-B planned rating of 3 as well as the ITE Room as defined by NFPA 75. As such, the Data Center Room 111 is are required to be protected by a clean agent fire extinguishing system. The cold aisle containment within Data Center Room 111 is also required to be protected by the system.

B. Design, installation and testing of a calculated automatic and manual fixed total flooding clean agent fire extinguishing system and releasing system in accordance with NFPA 2001, NFPA 72, NFPA 70, and NFPA 75 and manufacturer’s written instructions for the locations shown on the contract drawings. The installation shall include all mechanical, controls and electrical components necessary for a complete and operating clean agent fire suppression system.

C. The installation shall include all mechanical, controls and electrical components necessary for a complete and operating clean agent fire suppression system.

D. The new Clean Agent Room 107 will be the clean agent cylinder storage room.

E. Provide clean agent protection within both the hot-aisle containment and the main computer room. Detection shall be arranged in two separate cross-zone volumes. Activation of any two detectors within the same volume shall release agent to the entire protected space.
Maximum detector spacing shall not exceed 160 ft² coverage per device, reduced from 250 ft² per NFPA 72 Table 17.7.3.2.1(a) for 19-ft ceilings.

F. Coordinate CRAC unit shutdown and electronic equipment power shutdown as required by NFPA 75 9.4.2.1. Provide addressable interface modules to initiate the emergency power-off (EPO) function and supervise all power interlock and shutdown circuits per NFPA 72 10.17.5.

1.2 RELATED WORK

A. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES

B. Section 07 84 00, FIRESTOPPING

C. Section 09 91 00, PAINTING

D. Section 28 05 13, CONDUCTORS AND CABLES FOR ELECTRONIC SAFETY AND SECURITY

E. Section 28 05 28.33, CONDUIT AND BACKBOXES FOR ELECTRONIC SAFETY AND SECURITY

F. Section 28 31 00, FIRE DETECTION AND ALARM

1.3 DESIGN CRITERIA

A. The clean agent fire extinguishing system shall be a fixed total flooding type utilizing clean agent designed to provide a uniform concentration throughout the protected spaces in accordance with NFPA 2001 for a Class C fire.

1. The system shall provide a minimum design concentration by volume, throughout the protected spaces at the minimum anticipated temperature within the protected space.
2. The design concentration within any protected space shall not exceed by volume the no effects level (NEL). Special means such as mechanical exhaust, shall not be permitted to be used to achieve this criterion.
4. Provide the quantity of clean agent as required by NFPA 2001 and manufacturer’s written instructions. Such factors as unenclosed openings (if any), “rundown” time of fans, time required for dampers to close, and any other feature of the facility that could affect concentration shall be taken into consideration.
5. Provide seismic bracing for the clean agent fire extinguishing system components.
6. System shall utilize the ambient temperatures within the Data Center and the cold aisle containment as outlined in the mechanical CFD analysis within the construction documents.
7. Prepare complete system documentation in accordance with NFPA 2001 10.8, including but not limited to: system design drawings, agent weight calculations, retention-time verification, battery and voltage-drop calculations, commissioning test plan, and sequence of operations narrative. Provide the Record of Completion (NFPA 72 Form A.17.2.2) and the Certificate of Inspection and Maintenance (NFPA 2001 § 10.8.3) as part of the final submittal package.

1.4 SUBMITTALS

A. Submit as one package in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES. Prepare detailed working drawings that are signed by a NICET Level IV Special Hazards Suppression Systems Technician. As the Government review is for technical adequacy only, the installer remains responsible for correcting any conflicts with other trades and building construction that arise during installation. Partial submittals will not be accepted. Material submittals shall be approved prior to the purchase or delivery to the job site. Suitably bind submittals in notebooks or binders and provide an index referencing the appropriate specification section. In addition to the hard copies, provide submittal items in Paragraphs 1.4 (A) 1 through 1.4 (A) 5 electronically in pdf format on a compact disc or as directed by the Contracting Officers Representative (COR). Submittals shall include, but not be limited to, the following:

1. Qualifications:
   a. Provide a copy of the installing contractors state contractors license.
   b. Provide a copy of the NICET certification for the NICET Level IV Special Hazards Suppression System Technician who will prepare and sign the detailed working drawings.
   c. Provide documentation showing that the installer has been actively and successfully engaged in the installation of clean agent fire suppression systems for the past ten years.
2. Drawings: Submit detailed 1:100 (1/8 inch) scale (minimum) working plans and drawings of the clean agent fire extinguishing system conforming to NFPA 2001. Submit detailed 1:100 (1/8 inch) scale (minimum) working plans and drawings of the releasing system conforming to NFPA 72. Drawings shall include graphical scales that allow the user to determine lengths when the drawings are reduced in size.
3. Manufacturers Data Sheets:
   a. Provide for all materials and equipment proposed for use on the clean agent fire extinguishing system, including the releasing system. Include listing information and installation instructions in data sheets. Where data sheet describes items in addition to

that item being submitted, clearly identify proposed item on the sheet.

4. Calculation Sheets:
   a. Submit flow calculation sheets in tabular form conforming to the requirements of NFPA 2001. Calculations shall include total storage capacity, flooding concentrations, enclosure leakage rates, discharge times, flow through distribution network, pipe sizes, and nozzle orifice sizes.
   b. Submit battery calculations sheets in tabular form conforming to the requirements of NFPA 72.
   c. Submit voltage drop calculations in tabular form. Calculations shall indicate circuit amperage draw, wire resistance, circuit length, and voltage drop. The voltage drop shall demonstrate that voltage provided at the each appliance is within its operating voltage range. Voltage drop calculations shall assume an initial voltage of 20.4 volts.
   d. Submit calculations of loads for sizing of sway bracing.
5. Clean Agent Recharging Certification: Provide a letter to the COR or his designated representative certifying that the installer maintains or has access to a clean agent recharging station. The installer shall also provide proof of the ability to recharge the largest clean agent fire extinguishing system capacity within 48 hours.
6. Test Plan: Provide a test plan to the COR or his designated representative. The testing plan shall describe the procedures to be used to test the system. The testing plan shall include a step-by-step procedure of all tests to be performed, including indication of which tests will present a disruption to building occupants. No tests shall be conducted until the testing plan is approved by the COR or his designated representative.
7. Final Document Submittals: Provide as-built drawings, testing and maintenance instructions in accordance with the requirements in Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES. Submittals shall include, but not be limited to, the following:
   a. A complete set of as-built drawings showing the installed system with the specific interconnections between the system switches and the fire alarm equipment. Provide a complete set in the

formats as follows. Submit items 2 and 3 below on a compact disc or as directed by the COR.

1) One full size (or size as directed by the COR) printed copy.
2) One complete set in electronic pdf format.
3) One complete set in AutoCAD format or a format as directed by the COR.

b. System Certification: Upon completion of the clean agent fire extinguishing system installation, including testing, the authorized representative of the manufacturer of the major equipment shall certify that the installation complies with all manufacturer’s requirements and that satisfactory total system operation has been achieved. Provide a copy of the Record of Completion for the releasing system in accordance with NFPA 72.

c. Operating and Maintenance Manuals that include step-by-step procedures required for operation, shutdown, and routine maintenance and testing. The manuals shall include the manufacturer’s name, model number, parts list, the name of the local supplier, simplified wiring and controls diagrams, troubleshooting guide, and recommended service organization, including address and telephone number, for each item of equipment.

d. One paper copy of the System Certification and Record of Completion and the Operating and Maintenance Manuals listed above shall be provided in a binder. In addition, these materials shall be provided in pdf format on a compact disc or as directed by the COR.

e. Provide one additional copy of the Operations and Maintenance Manual for the system in a binder and mount in an accessible location adjacent to the storage cylinder(s).

1.5 QUALITY ASSURANCE

A. Installer Reliability: The installer shall possess a valid State of Maine contractor's license. The installer shall have been actively and successfully engaged in the installation of clean agent special suppression systems for the past ten years. The installer shall maintain or have access to a clean agent recharging station. The installer shall provide proof of the ability to recharge the largest clean agent fire extinguishing system capacity within 48 hours.

B. Materials and Equipment: All equipment and devices shall be UL listed or approved by FM. All materials, devices, and equipment shall be approved by the VA. All materials and equipment shall be free from defect.

1.6 APPLICABLE PUBLICATIONS

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

B. National Fire Protection Association (NFPA):

70-2020.....National Electric Code

72-2022.....National Fire Alarm Code

75-2020.....Fire Protection of Information Technology Equipment

170-2021.....Fire Safety Symbols

2001-2022.....Installation of Clean Agent Fire Extinguishing Systems

C. Underwriters Laboratories, Inc. (UL):

Contract Date..... Fire Protection Equipment Directory

D. Factory Mutual Engineering Corporation (FM):

Contract Date..... Approval Guide

1.7 WARRANTY

All work performed and all material and equipment furnished under this contract shall be free from defects and shall remain so for a period of one year from the date of acceptance of the entire installation by the COR.

PART 2 PRODUCTS

2.1 GENERAL

A. All equipment and components shall be new and the manufacturer’s current model. All equipment and components shall be UL listed or FM approved for its intended use. The authorized representative of the manufacturer of the major equipment shall certify that the installation complies with all manufacturer’s requirements and that satisfactory total system operation has been achieved.

B. Fire extinguishing agent shall be FK-5-1-12 (Novec 1230), HFC-227ea (FM-200) or IG 541 (Inergen.

2.2 CLEAN AGENT FIRE EXTINGUISHING SYSTEM

A. General:

1. The clean agent fire extinguishing system shall be IG-541 and shall be installed in accordance with NFPA 2001.

B. Piping and fittings:
   1. All piping and fittings shall be in compliance with NFPA 2001.
   2. Multi-outlet fittings, other than tees, shall not be permitted.
   3. All piping shall be reamed, blown clear, and swabbed with appropriate solvent to remove mill varnish and cutting oils before assembly.
   4. Ordinary cast iron steel and non-metallic piping and fittings and flexible hoses shall not be used unless specifically required by the manufacturer.

C. Piping Support:
   1. All piping shall be supported in accordance with the manufacturer’s written instructions.
   2. Piping shall be supported within 12 inches (304 mm) of discharge nozzles. The supports shall prevent the upward movement of the nozzle.
   3. Seismic bracing shall be installed.

D. Storage Cylinders:
   1. Provide storage cylinders as required by the manufacturer’s written instructions and in accordance with NFPA 2001.
   2. For 150 bar cylinders, each valve shall also include a safety pressure relief device, which provides relief at 3000 to 3360 psi (206.8 to 231.7 bar) per CGA test methods. Cylinder charging pressure is 2175 psi at 70 °F (150 bar at 21 °C).
   3. Cylinder assemblies shall be of steel construction designed to meet the requirements of the U.S. Department of Transportation.
   4. Filling of the storage cylinders shall be by an authorized systems distributor in conjunction with a factory authorized agent filling station. Initial filling and recharge shall be performed in accordance with manufacturer’s written instructions and shall not require replacement components for normal service.
   5. Cylinders shall be securely attached to the wall.
   6. Each cylinder assembly shall be furnished with a bracket made from welded steel. The bracket shall hold the cylinders in a saddle with a front bracket piece that secures the cylinders. The brackets shall

be modular in design to allow added bracketing or stacking of cylinders depending on installation requirements.

7. Cylinder brackets shall be UL listed and/or FM approved for use with the system.

E. Valve Actuators:

1. Electric valve actuators shall be of brass construction and stackable design with swivel connections to allow removal of actuators for maintenance or testing.
2. Operation of actuators shall not require replacement of components. No electro-explosive devices may be used to actuate the valve assembly. Actuators shall include an indication if they are set or actuated.
3. Electric valve actuators shall be magnetic latch, continuous duty type for 12 VDC operation.
4. Actuation devices shall be UL listed or FM approved for use with the system.
5. Removal of the electric valve actuator shall cause a trouble on the clean agent control panel.

F. Discharge Nozzles:

1. Acoustic damping discharge nozzles shall be used.
2. For acoustic sensitive installations, an acoustic impact evaluation should be performed specific to the hazard area being protected. The report shall include the sound power generated by the suppression system, room parameters and estimated sound pressure level impact on sensitive electronic equipment such as Hard Disc Drives.
3. The sound pressure level impact on Hard Disc Drives shall be below 110dbZ across the 1/3 octave sound bands from 500Hz to 10K Hz.
4. Discharge nozzles shall be constructed to provide flow rates in accordance with system design flow calculations.
5. The nozzles shall be threaded to the discharge piping via an orifice pipe assembly that includes the nozzle inlet orifice plate.
6. The nozzle orifice plate drill size shall be determined by a computerized UL listed flow calculation program.
7. Agent discharge orifice(s) shall be machined in the nozzle body to provide a horizontal discharge pattern based upon the approved coverage arrangements.

8. Sound control mechanisms shall be deployed as an integral element of the Acoustic Nozzles.
9. Nozzles shall be UL listed and the acoustic performance shall be UL verified as manufactured by Johnson Controls.

2.3 RELEASING SYSTEM

A. General

1. The releasing system shall be an analog addressable intelligent reporting, microprocessor controlled system, capable of remote sensitivity testing of the smoke detectors, and be installed in accordance with NFPA 70, NFPA 72, and NFPA 2001.

B. Clean Agent Control Panel:

1. General:
   a. The clean agent control panel shall be UL listed or FM approved and include a UL listed or FM approved releasing module.
   b. Each protected space shall be provided with its own clean agent control unit.
   c. All circuits shall be monitored for integrity.
   d. Visually and audibly annunciate all alarm, supervisory, and trouble signals including, but not limited to main power failure, open circuit, short circuit, ground faults, and system bypass activation.
   e. The panel or releasing module shall include a 0-60 second programmable timer.
   f. The clean agent control panel shall be provided with separate contacts to provide common supervisory, alarm, and trouble signals to the main building fire alarm system.
   g. Coordinate HVAC and electrical shutdowns in compliance with NFPA 75. Furnish all programming, control interfaces, wiring, and functional testing necessary to ensure automatic shutdown of CRAC units and all electronic equipment within the protected space upon clean agent system activation. Control emergency power off with addressable interface modules.

1. Enclosure:
   a. The clean agent control unit shall be housed in a cabinet suitable for both recessed and surface mounting. The cabinet and front panel shall be corrosion protected, given a rust-resistant prime coat, and manufacturer's standard finish.

b. The cabinet shall contain all necessary relays, terminals, lamps, and legend plates to provide control for the system.

2. Power Supply:
   a. The clean agent control unit shall derive its normal power from a 120 volt, 60 Hz dedicated supply connected to the emergency power system. Standby power shall be provided by a 24 volt DC battery as hereinafter specified. The normal power shall be transformed, rectified, coordinated, and interfaced with the standby battery and charger.
   b. The power supply for smoke detection systems shall be taken from the clean agent control unit.
3. Circuit Supervision: Each alarm initiating device circuit, signaling line circuit, and notification appliance circuit, shall be supervised against the occurrence of an open, short circuit, or ground fault condition in the field wiring. These conditions shall cause a trouble signal to sound in the control unit until manually silenced by an off switch.
   a. Initiating device circuits (IDC) shall be wired Class B in accordance with NFPA 72.
   b. Signaling line circuits (SLC) shall be wired Class B in accordance with NFPA 72.
   c. Notification appliance circuits (NAC) shall be wired Class B in accordance with NFPA 72.
5. Supervisory Alarm Devices: The low agent pressure switch and maintenance lock-out switch shall initiate a supervisory signal.
6. Trouble signals:
   a. Arrange the trouble signals for automatic reset (non-latching).
   b. System trouble switch off and on lamps shall be visible through the control unit door.
7. Function Switches: Provide the following switches in addition to any other switches required for the system:
   a. Remote Alarm Transmission By-pass Switch: Shall prevent transmission of all signals to the building fire alarm control unit when in the "off" position. A clean agent control unit system trouble signal shall be energized when switch is in the off position.

b. Alarm Off Switch: Shall disconnect power to notification appliance circuits on the clean agent control panel. A system trouble signal shall be activated when the switch is in the off position.

c. Trouble Silence Switch: Shall silence the trouble signal whenever the trouble silence switch is operated. This switch shall not reset the trouble signal.

d. Reset Switch: Shall reset the system after an alarm, provided the initiating device has been reset. The system shall lock in alarm until reset.

e. Lamp Test Switch: A test switch or other approved convenient means shall be provided to test the indicator lamps.

f. AHU By-Pass: Provide a means to disable air handling units shutdown and dampers from closing upon operation of an initiating device designed to interconnect with these devices. A system trouble signal shall be activated when switch is in the off position.

8. Reset Capability: Each clean agent control unit shall be installed and programmed so that each must be reset locally after an alarm, before the main fire alarm control unit can be reset.

C. Conduit, Boxes, and Wire

1. Conduit shall be in accordance with Section 28 05 28.33 CONDUIT AND BACKBOXES FOR ELECTRONIC SAFETY AND SECURITY and as follows:
   a. All new conduits shall be installed in accordance with NFPA 70.
   b. Conduit fill shall not exceed 40 percent of interior cross sectional area.
   c. All new conduits shall be 3/4 inch (19 mm) minimum.
2. Wire:
   a. Wiring shall be installed in conduit.
   b. Wiring shall be in accordance with NEC article 760, Section 28 05 13, CONDUCTORS AND CABLES FOR ELECTRONIC SAFETY AND SECURITY, and as recommended by the manufacturer of the fire alarm system. All wires shall be color coded. Number and size of conductors shall be as recommended by the fire alarm system manufacturer, but not less than 18 AWG for initiating device circuits and 14 AWG for notification appliance circuits.

c. Signaling line circuits shall be twisted and shielded unless other wiring methods are specifically required by the fire alarm equipment manufacturer in writing.

3. Terminal Boxes, Junction Boxes, and Cabinets:
   a. These shall be galvanized steel in accordance with UL requirements.
   b. All boxes shall be sized and installed in accordance with NFPA 70.
   c. Covers shall be repainted red in accordance with Section 09 91 00, PAINTING and shall be identified with white markings as "CA FA" or as directed by the COR for junction boxes and as "CLEAN AGENT FIRE ALARM SYSTEM" for cabinets and terminal boxes. Lettering shall be a minimum of 3/4 inch (19 mm) high.
   d. Terminal boxes and cabinets shall have a volume 50 percent greater than required by NFPA 70. Minimum sized wire shall be considered as 14 AWG for calculation purposes.
   e. Terminal boxes and cabinets shall have identified screw type terminal strips and shall be located in an accessible location. Terminal strips shall be labeled as to what circuit it is or as approved by the COR.

D. Standby Power Supply
   1. Batteries:
      a. The batteries shall be of the sealed, maintenance free type, 24-volt nominal.
      b. The batteries shall have sufficient capacity to power the clean agent control panel and its peripherals for not less than 24 hours plus 5 minutes of alarm to an end voltage of 1.14 volts per cell, upon a normal AC power failure.
      c. Battery racks shall be steel with an alkali-resistant finish.
   2. Battery Charger:
      a. The battery charger shall be completely automatic, with constant potential charger maintaining the battery fully charged under all service conditions. Charger shall operate from a 120-volt, 60 hertz emergency power source.
      b. The battery charger shall be rated for fully charging a completely discharged battery within 48 hours while simultaneously supplying any loads connected to the battery.

c. The battery charger shall have protection to prevent discharge through the charger.
d. The battery charger shall have protection for overloads and short circuits on both AC and DC sides.
e. A trouble condition shall actuate the fire alarm trouble signal.
f. The battery charger shall have automatic AC line voltage regulation, automatic current-limiting features, and adjustable voltage controls.

E. Spot-type Smoke Detectors
1. Smoke detectors shall be photoelectric plug-in type and UL listed for use with the clean agent control panel being furnished. Each detector shall be monitored individually, via an integral, analog addressable element.
2. Photoelectric detectors shall be factory calibrated and readily field adjustable. The sensitivity of any photoelectric detector shall be factory set at 3.0 plus or minus 0.25 percent obscuration per foot.
3. Smoke detectors of the protected spaces shall be spaced in accordance with NFPA 72 for high air movement areas. Air velocities within the protected spaces shall be suitable for the listed detection air velocity range of the smoke detector.

Each protected space shall have at least 2 detectors.

F. Manual Activation Stations:
1. Shall be non-break glass, address reporting type.
2. Station front shall be constructed of durable material such as cast or extruded metal or high impact plastic. Stations shall be semi-flush type.
3. Shall be of dual action pull down type with suitable operating instructions provided on front in raised or depressed letters, and clearly labeled “AGENT RELEASE.”
4. Operating handles shall be constructed of a durable material. On operation, the lever shall lock in alarm position and remain so until physically reset. A key shall be required to gain front access for resetting, or conducting tests and drills.
5. Shall be located at least 3.28 ft (1m) from any fire alarm manual pull station.

G. Notification Appliances:

1. Pre-discharge Bells:
   a. Shall be 24 VDC and be capable of producing an alarm signal of not less than 85 dBa at 10 feet.
   b. Shall be at least 6 inches (150 mm) in diameter.
2. Pre-discharge Strobes:
   a. Be listed in accordance with UL 1971.
   b. Shall be a minimum of 75 candela.
   c. Shall be provided with an amber lens.
   d. Shall be synchronized with other pre-discharge strobes in the protected space.
3. Discharge Strobes:
   a. Be listed in accordance with UL 1971.
   b. Shall be a minimum of 75 candela.
   c. Shall be provided with a red lens.
   d. Shall be synchronized with other discharge strobes outside the protected space.

H. Addressable Interface Module
1. Addressable interface modules shall be installed in individual boxes in accordance with the manufacturer’s product listing. The addressable interface module shall be provided with a protective cover provided by the device manufacturer. The protective cover shall have the provision for viewing the operational LED of the addressable interface module. Addressable interface modules shall not be installed in a back-box with other devices or relays.
2. The installer shall provide, install, and test addressable interface modules as necessary to comply with the sequence of operations, whether shown on the drawings or not.

I. Graphic Floor Plans:
1. Provide readable scaled graphics of the protected area. The graphics shall show the location and address of each the ceiling smoke detectors, above ceiling smoke detectors, and under floor smoke detectors, on separate plans.
2. The graphic shall be framed and shall be located in an area approved by the COR.
3. Where approved by the COR a single graphic floor plan shall be permitted.

J. Abort Switches:

1. The abort switch front shall be constructed of durable material such as cast or extruded metal or high impact plastic. The abort switch shall be semi-flush type.
2. The abort switch shall not be a locking or keyed type.
3. The abort switch shall be of single action dead-man spring loaded type with suitable operating instructions provided on front in raised or depressed letters, and clearly labeled "ABORT."

2.4 SWITCHES

A. Maintenance Lock-out Switch
1. Shall be key-operated only allowing the removal of the key in the "Normal" position. A red indicator lamp shall be included on the switch assembly to be illuminated when in the "Lock-out" position. The clean agent control panel shall indicate a supervisory alarm condition when in the "Lock-out" position.
2. The terminals shall be of the screw type.
3. Shall be provided adjacent to the clean agent control panel.

2.5 SIGNAGE

A. Signage shall have white lettering on a red plastic background.
B. The letters shall be 1 inch (25 mm) high with a stroke width of 3/8 inches (9.5 mm).
C. Provide engraved acrylic plaques with Helvetica Bold lettering.

2.6 PRESSURE RELIEF

A. The system shall be provided adequate pressure relief to safely relieve the anticipated peak pressures generated by the system during activation. Provide a peak pressure relief vent. Vent size to be calculated by the clean agent contractor and coordinated with mechanical contractor.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation shall be accomplished by the licensed contractor. Provide a factory trained qualified technician, experienced in the installation and operation of the type of system being installed, to supervise the installation and testing of the system.
B. Install clean agent fire extinguishing system piping and fittings level and plumb, according to manufacturer's written instructions.
C. Where installing piping adjacent to equipment, allow space for service and maintenance.

D. Identity piping, agent storage cylinders, and control panels with signage in accordance with NFPA 2001.

E. Provide signage for the pre-discharge bells and strobes. The sign shall say "FIRE. CLEAN AGENT RELEASE IS IMMINENT WHEN ACTIVE. EXIT AREA." The sign shall be permanently affixed to the wall within 12 inches (304 mm) of the pre-discharge bells and strobes.

F. Provide signage for the discharge strobes. The sign shall say "CLEAN AGENT DISCHARGE". The sign shall be permanently affixed to the wall within 12 inches (304 mm) of the discharge strobe.

G. Provide signage on the exterior of the protected space at each entrance to the data center room. The sign shall say "WARNING" and "THIS SPACE IS PROTECTED BY A CLEAN AGENT FIRE EXTINGUISHING SYSTEM. DO NOT ENTER WITHOUT AUTHORIZATION DURING OR AFTER DISCHARGE. THE RED STROBE INDICATES SYSTEM DISCHARGE." The sign shall be permanently affixed to the wall adjacent to the door.

H. Provide signage adjacent to each manual activation station. The sign shall say "CLEAN AGENT SYSTEM RELEASE" and "ACTUATION OF THIS DEVICE WILL CAUSE FIRE SUPPRESSION GAS TO DISCHARGE. BEFORE ACTUATING, ENSURE THAT PERSONNEL ARE CLEAR OF THE AREA." The sign shall be permanently affixed to the wall within 12 inches (304 mm) of the station.

I. Provide signage adjacent to each manual abort station. The sign shall say "CLEAN AGENT SYSTEM ABORT. PUSH AND HOLD TO ABORT CLEAN AGENT RELEASE". The sign shall be permanently affixed to the wall within 12 inches (304 mm) of the station.

J. Provide signage on the exterior of the clean agent cylinder storage room at each entrance. The sign shall say "CLEAN AGENT CYLINDER STORAGE ROOM." The sign shall be permanently affixed to the wall adjacent to the door.

K. Firestopping shall be provided for all penetrations of fire resistance rated construction. Firestopping shall comply with Section 07 84 00, FIRESTOPPING.

L. Repairs: Repair damage to the building or equipment resulting from the installation of the clean agent fire extinguishing system by the installer at no additional expense to the Government.

M. Supervise clean agent control panel for alarm, supervisory, and trouble signals by the building fire alarm system in accordance with Section 28 31 00, FIRE DETECTION AND ALARM.

N. Where duct detectors are provided within computer room air conditioning units, addressable interface modules shall be used to monitor the activation of the duct detector as a supervisory signal on the clean agent control unit.

O. Control emergency power off with addressable interface modules.

3.2 SEQUENCE OF OPERATIONS

A. The clean agent extinguishing fire extinguishing system shall operate as follows:

1. Activation of any single smoke detector shall:
   a. Energize an alarm LED lamp on the activated detector and clean agent control panel.
   b. Transmit an alarm signal to the building’s fire alarm system.
2. Activation of a second smoke detector shall:
   a. Energize an alarm LED lamp on the activator detector.
   b. Activate pre-discharge bell notification appliance and pre-discharge strobe notification appliance.
   c. Shut down power to electronic equipment within the protected space, close dampers, release door hold open devices, and shut down air handling units serving the protected space.
   d. Initiate a programmable 30-second time delay (agent release) sequence.
3. Activation of a manual activation station shall:
   a. Energize an alarm LED lamp on the clean agent control panel.
   b. Activate pre-discharge bell notification appliance and pre-discharge strobe notification appliance.
   c. Shut down power to electronic equipment within the protected space, close dampers, release door hold open devices, and shut down air handling units serving the protected space.
   d. Transmit an alarm signal to the building’s fire alarm system.
   e. Initiate a programmable 20-second time delay (agent release) sequence.
4. Activation of the abort switch shall:
   a. Cease the time delay. Once the abort switch is released, the time delay countdown shall resume from where it ceased. The time delay shall not reset.
   b. Transmit a trouble signal to the building’s fire alarm system.
5. Upon completion of the time delay, the system shall:

a. De-energize the pre-discharge bell and pre-discharge strobe notification appliance.
b. Activate a discharge strobe notification appliance inside and outside of the protected area.
c. Energize valve actuator for agent cylinders releasing gaseous agent into the protected area.

6. Activation of the low agent tank pressure switch and maintenance lock-out switch shall:
   a. Energize a supervisory LED lamp on the clean agent control panel.
   b. Transmit a supervisory alarm signal to the building's fire alarm system.
7. Presence of any fault, bypass function, or removal of the electric valve actuator shall:
   a. Energize a trouble LED lamp on the clean agent control panel.
   b. Transmit a trouble signal to the building's fire alarm system.
8. Activation of duct detector within a computer room air condition unit shall energize a supervisory signal LED lamp on the clean agent control panel.

3.3 INSPECTION, TESTING, AND COMMISSIONING

A. Room Enclosure Test: A room pressurization test shall be conducted for the protected space. The testing shall be done in accordance with NFPA 2001 Annex C. The contractor shall be responsible for sealing the enclosure to ensure the success of the room pressurization test. The test shall be deemed successful if the tested leakage rate is less than or equal to the leakage rate assumed in the calculations.

B. Pressure Test: Pneumatically pressure test piping in a closed circuit in accordance with NFPA 2001.

C. Flow Test: Subject system to a flow test utilizing nitrogen to verify that flow is continuous and that the piping and nozzles are unobstructed.

D. Preliminary Testing and Commissioning: System function operation test system as specified in NFPA 2001 and NFPA 72, in the presence of the COR or his designated representative. This includes but not limited to:
   1. System Verification: Inspect all components of the clean agent fire suppression system (agent storage containers, distribution piping, detection devices, releasing panel, nozzles, and alarms) to confirm compliance with the approved design drawings, equipment submittals,

and NFPA 2001 requirements. Verify agent type, container pressures, and cylinder weights to ensure they match the specified system design and manufacturer's data.

2. Installation Checks: Confirm that piping and nozzle placements align with NFPA 2001 coverage and spacing criteria, including height, clearance, and hazard area volume. Inspect all detection, control, and alarm components for correct mounting, wiring, labeling, and connectivity to the releasing panel.
3. Functional Testing: Perform a full system operational test in accordance with NFPA 2001, including activation from each initiating device. Check that all audible and visual alarms operate correctly and that automatic shutdown or damper closure (if applicable) occurs as designed. Verify releasing panel interfaces with building systems (e.g., HVAC shutoff, dampers,) and confirm the agent discharge sequence. Include full verification of the sequence of operation required by Section 3.2.
4. Documentation: Provide final a written report of commissioning activities.

E. Final Inspection and Testing: Subject system to tests in accordance with NFPA 2001 and NFPA 72, and when all necessary corrections have been accomplished, advise COR to schedule a final inspection and test. Connection to the fire alarm system shall have been in service for at least ten days prior to the final inspection, with adjustments made to prevent false alarms. Furnish all instruments, labor and materials required for the tests and provide the services of the installation foreman or other competent representative of the installer to perform the tests. Correct deficiencies and retest system as necessary, prior to the final acceptance. Include the operation of all features of the systems under normal operations in test.

3.4 TRAINING

A. The manufacturer's authorized representative shall provide instruction and training to the VA on the dates requested by the COR as follows:
1. Six 1-hour sessions to employees working in protected area, engineering staff, security police and VA Fire Department personnel where there is a VA Fire Department present on site for simple operation of the system. Two sessions at the start of installation,

2 sessions at the completion of installation and 2 sessions 3 months after the completion of installation.

2. Four 2-hour sessions to engineering staff for detailed operation of the system. Two sessions at the completion of installation and 2 sessions 3 months after the completion of installation.
3. Three 8-hour sessions to electrical technicians for maintaining, programming, modifying, and repairing the system at the completion of installation and one 8-hour refresher session 3 months after the completion of installation.

B. Each initial training session shall be videotaped.

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SECTION 22 05 11
COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.1 DESCRIPTION

A. The requirements of this Section shall apply to all sections of Division 22.

1.2 DEFINITIONS

A. Exposed: Piping and equipment exposed to view in finished rooms.

B. Exterior: Piping and equipment exposed to weather be it temperature, humidity, precipitation, wind or solar radiation.

C. Option or optional: Contractor's choice of an alternate material or method.

D. Provide: Furnish and install.

1.3 ABBREVIATIONS/ACRONYMS

A. ABS: Acrylonitrile Butadiene Styrene

B. AC: Alternating Current

C. ACR: Air Conditioning and Refrigeration

D. A/E: Architect/Engineer

E. AFF: Above Finish Floor

F. AFG: Above Finish Grade

G. AI: Analog Input

H. AISI: American Iron and Steel Institute

I. AO: Analog Output

J. ASHRAE: American Society of Heating, Refrigeration, & Air Conditioning Engineers

K. ASJ: All Service Jacket

L. ASME: American Society of Mechanical Engineers

M. ASPE: American Society of Plumbing Engineers

N. AWG: American Wire Gauge

O. BACnet: Building Automation and Control Network

P. BAg: Silver-Copper-Zinc Brazing Alloy

Q. BAS: Building Automation System

R. BCuP: Silver-Copper-Phosphorus Brazing Alloy

S. bhp: Brake Horsepower

T. Btu: British Thermal Unit
U. Btu/h: British Thermal Unit per Hour
V. BSG: Borosilicate Glass Pipe
W. C: Celsius
X. CA: Compressed Air
Y. CD: Compact Disk
Z. CDA: Copper Development Association
AA. CGA: Compressed Gas Association
BB. CFM: Cubic Feet per Minute
CC. CI: Cast Iron
DD. CLR: Color
EE. CO: Contracting Officer
FF. COR: Contracting Officer’s Representative
GG. CPVC: Chlorinated Polyvinyl Chloride
HH. CR: Chloroprene
II. CRS: Corrosion Resistant Steel
JJ. CWP: Cold Working Pressure
KK. CxA: Commissioning Agent
LL. dB: Decibels
MM. db(A): Decibels (A weighted)
NN. DCW: Domestic Cold Water
OO. DDC: Direct Digital Control
PP. DFU: Drainage Fixture Units
QQ. DHW: Domestic Hot Water
RR. DHWR: Domestic Hot Water Return
SS. DHWS: Domestic How Water Supply
TT. DI: Digital Input
UU. DI: Deionized Water
VV. DISS: Diameter Index Safety System
WW. DN: Diameter Nominal
XX. DO: Digital Output
YY. DOE: Department of Energy
ZZ. DVD: Digital Video Disc
AAA. DWG: Drawing
BBB. DWH: Domestic Water Heater

CCC. DWS: Domestic Water Supply

DDD. DWV: Drainage, Waste and Vent

EEE. ECC: Engineering Control Center

FFF. EL: Elevation

GGG. EMCS: Energy Monitoring and Control System

HHH. EPA: Environmental Protection Agency

III. EPACT: Energy Policy Act

JJJ. EPDM: Ethylene Propylene Diene Monomer

KKK. EPT: Ethylene Propylene Terpolymer

LLL. ETO: Ethylene Oxide

MMM. F: Fahrenheit

NNN. FAR: Federal Acquisition Regulations

OOO. FD: Floor Drain

PPP. FDC: Fire Department (Hose) Connection

QQQ. FED: Federal

RRR. FG: Fiberglass

SSS. FNPT: Female National Pipe Thread

TTT. FOR: Fuel Oil Return

UUU. FOS: Fuel Oil Supply

VVV. FOV: Fuel Oil Vent

WWW. FPM: Fluoroelastomer Polymer

XXX. FSK: Foil-Scrim-Kraft Facing

YYY. FSS: VA Construction & Facilities Management, Facility Standards Service

ZZZ. FU: Fixture Units

AAAA. GAL: Gallon

BBBB. GCO: Grade Cleanouts

CCCC. GPD: Gallons per Day

DDDD. GPH: Gallons per Hour

EEEE. GPM: Gallons per Minute

FFFF. HDPE: High Density Polyethylene

GGGG. HEFP: Healthcare Environment and Facilities Program (replacement for OCAMES)

HHHH. HEX: Heat Exchanger

IIII. Hg: Mercury

JJJJ. HOA: Hands-Off-Automatic

KKKK. HP: Horsepower

LLLL. HVE: High Volume Evacuation

MMMM. Hz: Hertz

NNNN. ID: Inside Diameter

OOOO. IE: Invert Elevation

PPPP. INV: Invert

QQQQ. IPC: International Plumbing Code

RRRR. IPS: Iron Pipe Size

SSSS. IW: Indirect Waste

TTTT. IWH: Instantaneous Water Heater

UUUU. Kg: Kilogram

VVVV. kPa: Kilopascal

WWWW. KW: Kilowatt

XXXX. KWH: Kilowatt Hour

YYYY. lb: Pound

ZZZZ. lbs/hr: Pounds per Hour

AAAAA. LNG: Liquid Natural Gas

BBBBB. L/min: Liters per Minute

CCCCC. LOX: Liquid Oxygen

DDDDD. L/s: Liters per Second

EEEEE. m: Meter

FFFFF. MA: Medical Air

GGGGG. MAWP: Maximum Allowable Working Pressure

HHHHH. MAX: Maximum

IIIII. MBH: 1000 Btu per Hour

JJJJJ. MED: Medical

KKKKK. MER: Mechanical Equipment Room

LLLLL. MFG: Manufacturer

MMMMM. mg: Milligram

NNNNN. mg/L: Milligrams per Liter

OOOOO. ml: Milliliter

PPPPP. mm: Millimeter

QQQQQ. MIN: Minimum

RRRRR. MV: Medical Vacuum

SSSSS. N2: Nitrogen

TTTTT. N20: Nitrogen Oxide

UUUUU. NC: Normally Closed

VVVVV. NF: Oil Free Dry (Nitrogen)

WWWWW. NG: Natural Gas

XXXXX. NIC: Not in Contract

YYYYY. NO: Normally Open

ZZZZZ. NOM: Nominal

AAAAAA. NPTF: National Pipe Thread Female

BBBBBB. NPS: Nominal Pipe Size

CCCCCC. NPT: Nominal Pipe Thread

DDDDDD. NTS: Not to Scale

EEEEEE. O2: Oxygen

FFFFFF. OC: On Center

GGGGGG. OD: Outside Diameter

HHHHHH. OSD: Open Sight Drain

IIIIII. OS&Y: Outside Stem and Yoke

JJJJJJ. PA: Pascal

KKKKKK. PBPU: Prefabricated Bedside Patient Units

LLLLLL. PD: Pressure Drop or Difference

MMMMMM. PDI: Plumbing and Drainage Institute

NNNNNN. PH: Power of Hydrogen

OOOOOO. PID: Proportional-Integral-Differential

PPPPPP. PLC: Programmable Logic Controllers

QQQQQQ. PP: Polypropylene

RRRRRR. ppb: Parts per Billion

SSSSSS. ppm: Parts per Million

TTTTTT. PSI: Pounds per Square Inch

UUUUUU. PSIA: Pounds per Square Inch Atmosphere

VVVVVV. PSIG: Pounds per Square Inch Gauge

WWWWWW. PTFE: Polytetrafluoroethylene

XXXXXX. PVC: Polyvinyl Chloride

YYYYYY. PVDF: Polyvinylidene Fluoride

ZZZZZZ. RAD: Radians

AAAAAAA.RO: Reverse Osmosis

BBBBBBB.RPM: Revolutions Per Minute

CCCCCCC.RTD: Resistance Temperature Detectors

DDDDDDD.RTRP: Reinforced Thermosetting Resin Pipe

EEEEEEE.SAN: Sanitary Sewer

FFFFFFF.SCFM: Standard Cubic Feet per Minute

GGGGGGG.SDI: Silt Density Index

HHHHHHH.SMACNA: Sheet Metal and Air Conditioning Contractors National Association

IIIIIII.SPEC: Specification

JJJJJJJ.SPS: Sterile Processing Services

KKKKKKK.SQFT/SF: Square Feet

LLLLLLL.SS: Stainless Steel

MMMMMMM.STD: Standard

NNNNNNN.SUS: Saybolt Universal Second

OOOOOOO.SWP: Steam Working Pressure

PPPPPPP.TD: Temperature Difference

QQQQQQQ.TDH: Total Dynamic Head

RRRRRRR.TEFC: Totally Enclosed Fan-Cooled

SSSSSSS.TEMP: Temperature

TTTTTTT.TFE: Tetrafluoroethylene

UUUUUUU.THERM: 100,000 Btu

VVVVVVV.THHN: Thermoplastic High-Heat Resistant Nylon Coated Wire

WWWWWWW.THWN: Thermoplastic Heat & Water Resistant Nylon Coated Wire

XXXXXXX.TIL: Technical Information Library
http//www.cfm.va.gov/til/indes.asp

YYYYYYY.T/P: Temperature and Pressure

ZZZZZZZ.TYP: Typical

AAAAAAAA. USDA: U.S. Department of Agriculture

BBBBBBBB. V: Vent

CCCCCCCC. V: Volt

DDDDDDDD. VA: Veterans Administration

EEEEEEEE. VA CFM: VA Construction & Facilities Management

FFFFFFFF. VA CFM CSS: VA Construction & Facilities Management, Consulting Support Service

GGGGGGGG. VAC: Vacuum

HHHHHHHH. VAC: Voltage in Alternating Current

IIIIIIII. VAMC: Veterans Administration Medical Center

JJJJJJJJ. VHA OCAMES: This has been replaced by HEFP.

KKKKKKKK. VSD: Variable Speed Drive

LLLLLLLL. VTR: Vent through Roof

MMMMMMMM. W: Waste

NNNNNNNN. WAGD: Waste Anesthesia Gas Disposal

OOOOOOOO. WC: Water Closet

PPPPPPPP. WG: Water Gauge

QQQQQQQQ. WOG: Water, Oil, Gas

RRRRRRRR. WPD: Water Pressure Drop

SSSSSSSS. WSFU: Water Supply Fixture Units

1.4 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

C. Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT.

D. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

E. Section 03 30 00, CAST-IN-PLACE CONCRETE.

F. Section 05 50 00, METAL FABRICATIONS.

G. Section 07 84 00, JOINT FIRESTOPPING.

H. Section 07 84 13, PENETRATION FIRESTOPPING.

I. Section 07 92 00, JOINT SEALANTS.

J. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

K. Section 22 07 11, PLUMBING INSULATION.

L. Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

M. Section 23 09 23, DIRECT DIGITAL CONTROLS FOR HVAC.

N. Section 23 81 23, COMPUTER-ROOM AIR-CONDITIONERS.

O. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS

P. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES.

Q. Section 31 20 11, EARTHWORK.

1.5 APPLICABLE PUBLICATIONS

A. The publications listed below shall form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Where conflicts occur these specifications and the VHA standard will govern.

B. American Society of Mechanical Engineers (ASME):
   1. B31.1-2013 Power Piping
   2. BPVC Section IX-2019 Boiler and Pressure Vessel Code - Welding, Brazing, and Fusing Qualifications

C. American Society for Testing and Materials (ASTM):
   1. A36/A36M-2019 Standard Specification for Carbon Structural Steel
   2. A575-96(2013)e1 Standard Specification for Steel Bars, Carbon, Merchant Quality, M-Grades
   3. E84-2013a Standard Test Method for Surface Burning Characteristics of Building Materials
   4. E119-2012a Standard Test Methods for Fire Tests of Building Construction and Materials

D. International Code Council, (ICC):
   1. IBC-2021 International Building Code
   2. IPC-2021 International Plumbing Code

E. Manufacturers Standardization Society (MSS) of the Valve and Fittings Industry, Inc:
   1. SP-58-2018 Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application and Installation

F. Military Specifications (MIL):
   1. P-21035B Paint High Zinc Dust Content, Galvanizing Repair (Metric)

G. National Electrical Manufacturers Association (NEMA):
   1. MG 1-2016 Motors and Generators

H. National Fire Protection Association (NFPA):
   1. 51B-2019 Standard for Fire Prevention During Welding, Cutting and Other Hot Work
   2. 54-2018 National Fuel Gas Code
   3. 70-2020 National Electrical Code (NEC)
   4. 99-2018 Healthcare Facilities Code

I. NSF International (NSF):

1. 5-2019 Water Heaters, Hot Water Supply Boilers, and Heat Recovery Equipment
2. 14-2019 Plastic Piping System Components and Related Materials
3. 61-2019 Drinking Water System Components - Health Effects
4. 372-2016 Drinking Water System Components - Lead Content

J. Department of Veterans Affairs (VA):
1. PG-18-10-2018 Plumbing Design Manual
2. PG-18-13-2018 Barrier Free Design Guide

1.6 QUALITY ASSURANCE

A. Plumbing, mechanical, electrical, and associated systems shall be safe, reliable, efficient, durable, easily and safely operable and maintainable, easily and safely accessible, and in compliance with applicable codes as specified. The systems shall be comprised of high-quality institutional-class and industrial-class products of manufacturers that are experienced specialists in the required product lines. All construction firms and personnel shall be experienced and qualified specialists in industrial and institutional plumbing.

B. Products Criteria:
1. Standard Products: Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products for at least 3 years.
2. Equipment Service: There shall be permanent service organizations, authorized and trained by manufacturers of the equipment supplied, located within 160 km (100 miles) of the project.
3. All items furnished shall be free from defects that would adversely affect the performance, maintainability, and appearance of individual components and overall assembly.
4. The products and execution of work specified in Division 22 shall conform to the referenced codes and standards. Local code officials and local authorities (such as the natural gas supplier) shall enforce local codes. If the local codes are more stringent, then the local codes shall apply. Any conflicts shall be brought to the attention of the Contracting Officer's Representative (COR) before executing the work.

5. Multiple Units: When two or more units of materials or equipment of the same type or class are required, these units shall be products of one manufacturer.
6. Assembled Units: Manufacturers of equipment assemblies, which use components made by others, assume complete responsibility for the final assembled product.
7. Nameplates: Nameplate bearing manufacturer's name or identifiable trademark shall be securely affixed in a conspicuous place on plumbing fixtures and equipment, or name or trademark cast integrally with same, stamped or otherwise permanently marked on each item.
8. Asbestos products or equipment or materials containing asbestos shall not be used.

C. Welding: Before any welding is performed, Contractor shall submit a certificate certifying that welders comply with the following requirements:
1. Qualify welding processes and operators for piping according to ASME BPVC, Section IX, "Welding and Brazing Qualifications." Provide proof of current certification to CO.
2. Comply with provisions of ASME B31 series "Code for Pressure Piping."
3. Certify that each welder and welding operator has passed American Welding Society (AWS) qualification tests for the welding processes involved, and that certification is current.
4. All welds shall be stamped according to the provisions of the AWS or ASME as required herein and by the association code.

D. Manufacturer's Recommendations: Where installation procedures or any part thereof are required to be in accordance with the recommendations of the manufacturer of the material being installed, printed copies of these recommendations shall be furnished to the COR prior to installation. Installation of the item will not be allowed to proceed until the recommendations are received. Failure to furnish these recommendations can be cause for rejection of the material.

E. Execution (Installation, Construction) Quality:

1. All items shall be applied and installed in accordance with the manufacturer's written instructions. Conflicts between the manufacturer's instructions and the contract drawings and specifications shall be referred to the COR for resolution. Written hard copies or computer files of the manufacturer’s installation instructions shall be provided to the COR at least two weeks prior to commencing installation of any item.
2. All items that require access, such as for operating, cleaning, servicing, maintenance, and calibration, shall be easily and safely accessible by persons standing at floor level, or standing on permanent platforms, without the use of portable ladders. Examples of these items include, but are not limited to: all types of valves, and strainers. Prior to commencing installation work, refer conflicts between this requirement and contract documents to COR for resolution.
3. Installer Qualifications: Installer shall be licensed and shall provide evidence of the successful completion of at least five projects of equal or greater size and complexity. Provide tradesmen skilled in the appropriate trade.
4. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no additional cost or additional time to the Government.
5. Provide complete layout coordination drawings. See Paragraph, SUBMITTALS. Construction work shall not start on any system until these drawings have been accepted.

F. Guaranty: Warranty of Construction, FAR clause 52.246-21.

G. Plumbing Systems: IPC, International Plumbing Code. Unless otherwise required herein, perform plumbing work in accordance with the latest version of the IPC. For IPC 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” or “owner” shall be interpreted to mean the COR.

1.7 SUBMITTALS

A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.

B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 22 05 11, COMMON WORK RESULTS FOR PLUMBING," with applicable paragraph identification.

C. If the project is phased, contractors shall submit complete phasing plan/schedule with manpower levels prior to commencing work. The phasing plan shall be detailed enough to provide milestones in the process that can be verified.

D. Contractor shall make all necessary field measurements and investigations to assure that the equipment and assemblies will meet contract requirements, and all equipment that requires regular maintenance, calibration, etc. are accessible from the floor or permanent work platform. It is the Contractor' s responsibility to ensure all submittals meet the VA specifications and requirements and it is assumed by the VA that all submittals do meet the VA specifications unless the Contractor has requested a variance in writing and approved by COR prior to the submittal. If at any time during the project it is found that any item does not meet the VA specifications and there was no variance approval the Contractor shall correct at no additional cost or time to the Government even if a submittal was approved.

E. If equipment is submitted which differs in arrangement from that shown, provide documentation proving equivalent performance, design standards and drawings that show the rearrangement of all associated systems. Additionally, any impacts on ancillary equipment or services such as foundations, piping, and electrical shall be the Contractor’s responsibility to design, supply, and install at no additional cost or time to the Government. VA approval will be given only if all features of the equipment and associated systems, including accessibility, are equivalent to that required by the contract.

F. Prior to submitting shop drawings for approval, Contractor shall certify in writing that manufacturers of all major items of equipment have each reviewed drawings and specifications, and have jointly coordinated and properly integrated their equipment and controls to provide a complete and efficient installation.

G. Submittals and shop drawings for interdependent items, containing applicable descriptive information, shall be furnished together and complete in a group. Coordinate and properly integrate materials and equipment in each group to provide a completely compatible and efficient installation. Final review and approvals will be made only by groups.

H. Manufacturer's Literature and Data including: Manufacturer’s literature shall be submitted under the pertinent section rather than under this section.
   1. Electric motor data and variable speed drive data shall be submitted with the driven equipment.
   2. Equipment and materials identification.
   3. Firestopping materials.
   4. Hangers, inserts, supports and bracing. Provide load calculations for variable spring and constant support hangers.
   5. Wall, floor, and ceiling plates.

I. Coordination/Shop Drawings:
   1. Submit complete consolidated and coordinated shop drawings for all new systems, and for existing systems that are in the same areas.

2. The coordination/shop drawings shall include plan views, elevations and sections of all systems and shall be on a scale of not less than 1:32 (3/8-inch equal to 1 foot). Clearly identify and dimension the proposed locations of the principal items of equipment. The drawings shall clearly show locations and adequate clearance for all equipment, piping, valves, control panels and other items. Show the access means for all items requiring access for operations and maintenance. Provide detailed coordination/shop drawings of all piping and duct systems. The drawings should include all lockout/tagout points for all energy/hazard sources for each piece of equipment. Coordinate lockout/tagout procedures and practices with local VA requirements.
3. Do not install equipment foundations, equipment or piping until coordination/shop drawings have been approved.
4. In addition, for plumbing systems, provide details of the following:
   a. Hangers, inserts, supports, and bracing.
   b. Pipe sleeves.
   c. Piping or equipment penetrations of floors, walls, ceilings, or roofs.

J. Rigging Plan: Provide documentation of the capacity and weight of the rigging and equipment intended to be used. The plan shall include the path of travel of the load, the staging area and intended access, and qualifications of the operator and signal person.

K. Plumbing Maintenance Data and Operating Instructions:
1. Maintenance and operating manuals in accordance with Section 01 00 00, GENERAL REQUIREMENTS, Article, INSTRUCTIONS, for systems and equipment.
2. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replacement parts, and troubleshooting guide:
   a. Include complete list indicating all components of the systems.
   b. Include complete diagrams of the internal wiring for each item of equipment.

c. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

3. Provide a listing of recommended replacement parts for keeping in stock supply, including sources of supply, for equipment. Include in the listing belts for equipment: Belt manufacturer, model number, size and style, and distinguished whether of multiple belt sets.

L. Provide copies of approved plumbing equipment submittals to the TAB and Commissioning Subcontractor.

M. Completed System Readiness Checklist provided by the CxA and completed by the Contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

N. Submit training plans, trainer qualifications and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

1.8 DELIVERY, STORAGE AND HANDLING

A. Protection of Equipment:

1. Equipment and material placed on the job site shall remain in the custody of the Contractor until phased acceptance, whether or not the Government has reimbursed the Contractor for the equipment and material. The Contractor is solely responsible for the protection of such equipment and material against any damage.

2. Damaged equipment shall be replaced with an identical unit as determined and directed by the COR. Such replacement shall be at no additional cost to the Government.

3. Interiors of new equipment and piping systems shall be protected against entry of foreign matter. Both inside and outside shall be cleaned before painting or placing equipment in operation.

4. Existing equipment and piping being worked on by the Contractor shall be under the custody and responsibility of the Contractor and shall be protected as required for new work.

5. Protect plastic components, piping, equipment, and tanks from ultraviolet light (sunlight) while in pre-construction. Plastic piping and tanks shall not be installed exposed to sunlight without metal jacketing to block ultraviolet rays.

B. Cleanliness of Piping and Equipment Systems:

1. Care shall be exercised in the storage and handling of equipment and piping material to be incorporated in the work. Debris arising from cutting, threading and welding of piping shall be removed.

1.9 AS-BUILT DOCUMENTATION

A. Submit manufacturer’s literature and data updated to include submittal review comments and any equipment substitutions.

B. Submit operation and maintenance data updated to include submittal review comments, substitutions and construction revisions shall be in electronic version on CD or DVD inserted into a three ring binder. All aspects of system operation and maintenance procedures, including piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices such as damper and door closure interlocks shall be included. A list of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.

C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the ' third party testing company' requirement.

D. The as-built drawings shall indicate the location and type of all lockout/tagout points for all energy sources for all equipment and pumps to include breaker location and numbers, valve tag numbers, etc. Coordinate lockout/tagout procedures and practices with local VA requirements.

E. As-built drawings:

1. As-built drawings are to be provided, and a copy of them on Auto-Cad version 2018 or newer provided on compact disk or DVD.

F. Certification documentation shall be provided to COR 21 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and provide documentation/certification that all results of tests were within limits specified. Test results shall contain written sequence of test procedure with written test results annotated at each step along with the expected outcome or setpoint. The results shall include all readings, including but not limited to data on device (make, model and performance characteristics), normal pressures, switch ranges, trip points, amp readings, and calibration data to include equipment serial numbers or individual identifications, etc.

G. The as-built drawings shall indicate the location and type of all lockout/tagout points for all energy sources for all equipment and pumps to include breaker location and numbers, valve tag numbers, etc. Coordinate lockout/tagout procedures and practices with local VA requirements.

1.10 JOB CONDITIONS - WORK IN EXISTING BUILDINGS

A. Building Operation: Refer to Division 1 for building operation information for the facility.

B. Maintenance of Service: Refer to Division 1 for requirements regarding work hours and interruption of programs/service at the facility.

C. Building Working Environment: Maintain the architectural and structural integrity of the building and the working environment at all times. Maintain the interior of building at 18 degrees C (65 degrees F) minimum. Limit the opening of doors, windows or other access openings to brief periods as necessary for rigging purposes. Storm water or ground water leakage is prohibited. Provide daily clean-up of construction and demolition debris on all floor surfaces and on all equipment being operated by VA. Maintain all egress routes and safety systems/devices.

D. Acceptance of Work for Government Operation: As new equipment, systems and facilities are made available for operation and these items are deemed of beneficial use to the Government, inspections will be made and tests will be performed. Based on the inspections, a list of contract deficiencies will be issued to the Contractor. After correction of deficiencies as necessary for beneficial use, the Contracting Officer will process necessary acceptance and the equipment will then be under the control and operation of Government personnel.

PART 2 - PRODUCTS

2.1 MATERIALS FOR VARIOUS SERVICES

A. 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 61 or NSF 372.

B. In-line devices such as check valves, fittings, and backflow preventers shall comply with NSF 61 and NSF 372.

2.2 FACTORY-ASSEMBLED PRODUCTS

A. Standardization of components shall be maximized to reduce spare part requirements.

B. Manufacturers of equipment assemblies that include components made by others shall assume complete responsibility for final assembled unit.

1. All components of an assembled unit need not be products of same manufacturer.

2. Constituent parts that are alike shall be products of a single manufacturer.
3. Components shall be compatible with each other and with the total assembly for intended service.
4. Contractor shall guarantee performance of assemblies of components, and shall repair or replace elements of the assemblies as required to deliver specified performance of the complete assembly.

C. Components of equipment shall bear manufacturer's name and trademark, model number, serial number and performance data on a name plate securely affixed in a conspicuous place, or cast integral with, stamped or otherwise permanently marked upon the components of the equipment.

D. Major items of equipment, which serve the same function, shall be the same make and model.

2.3 COMPATIBILITY OF RELATED EQUIPMENT

A. Equipment and materials installed shall be compatible in all respects with other items being furnished and with existing items so that the result will be a complete and fully operational system that conforms to contract requirements.

2.4 LIFTING ATTACHMENTS

Equipment shall be provided with suitable lifting attachments to enable equipment to be lifted in its normal position. Lifting attachments shall withstand any handling conditions that might be encountered, without bending or distortion of shape, such as rapid lowering and braking of load.

2.5 EQUIPMENT AND MATERIALS IDENTIFICATION

A. Interior (Indoor) Equipment: Engraved nameplates, with letters not less than 48 mm (3/16-inch) high of brass with black-filled letters or rigid black plastic with white letters shall be permanently fastened to the equipment. Unit components such as pumps and similar items, shall be identified.

B. Exterior (Outdoor) Equipment: Brass nameplates, with engraved black filled letters, not less than 48 mm (3/16-inch) high riveted or bolted to the equipment.

C. Control Items: All temperature, pressure, and controllers shall be labeled and the component's function identified. Identify and label each item as they appear on the control diagrams.

D. Pipe Markers:

1. Pipe markers shall include system label and flow direction.
2. Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings.
3. Color code as follows:
   a. Potable, Cooling, Boiler, Feed, Other Water: Green with white letters.
   b. Drain, Waste, Vent: Yellow with black letters.

E. Valve Tags and Lists:

1. Plumbing: All valves shall be provided with valve tags and listed on a valve list (Fixture stops not included).
2. Valve tags: Engraved black filled numbers and letters not less than 13 mm (1/2-inch) high for number designation, and not less than 6.4 mm(1/4-inch) for service designation on 19 gage, 38 mm (1-1/2 inches) round brass disc, attached with brass "S" hook or brass chain.
3. Valve lists: Valve lists shall be created using a word processing program and printed on plastic coated cards. The plastic coated valve list card(s), sized 216 mm (8-1/2 inches) by 280 mm (11 inches) shall show valve tag number, valve function and area of control for each service or system. The valve list shall be in a punched 3-ring binder notebook. A copy of the valve list shall be mounted in picture frames for mounting to a wall.
   a. COR shall instruct contractor where frames shall be mounted.
4. A detailed plan for each floor of the building indicating the location and valve number for each valve shall be provided. Each valve location shall be identified with a color coded sticker or thumb tack in ceiling.

2.6 FIRESTOPPING

A. Refer to Section 07 84 00, FIRESTOPPING, for requirements where piping penetrates rated assemblies.

B. Refer to Section 22 07 11, PLUMBING INSULATION, for pipe insulation requirements at penetrations of rated assemblies.

2.7 GALVANIZED REPAIR COMPOUND

A. Mil. Spec. DOD-P-21035B, paint.

2.8 PIPE AND EQUIPMENT SUPPORTS AND RESTRAINTS

A. Type Numbers Specified: For materials, design, manufacture, selection, application, and installation refer to MSS SP-58.

1. Refer to Section 05 50 00, METAL FABRICATIONS, for miscellaneous metal support materials and prime coat painting.

B. For Attachment to Concrete Construction:

1. Concrete insert: Type 18, MSS SP-58.
2. Self-drilling expansion shields and machine bolt expansion anchors: Permitted in concrete not less than 102 mm (4 inches) thick when approved by the COR for each job condition.
3. Power-driven fasteners: Permitted in existing concrete or masonry not less than 102 mm (4 inches) thick when approved by the COR for each job condition.

C. For Attachment to Steel Construction: MSS SP-58.

1. Welded attachment: Type 22.
2. Beam clamps: Types 20, 21, 28 or 29. Type 23 C-clamp may be used for individual copper tubing up to 23 mm (7/8-inch) outside diameter.

D. For Attachment to Wood Construction: Wood screws or lag bolts.

E. Hanger Rods: Hot-rolled steel, ASTM A36 or A575 for allowable load listed in MSS SP-58. For piping, provide adjustment means for controlling level or slope. Types 13 or 15 turn-buckles shall provide 38 mm (1-1/2 inches) minimum of adjustment and incorporate locknuts. All-thread rods are acceptable.

F. Multiple (Trapeze) Hangers: Galvanized, cold formed, lipped steel channel horizontal member, not less than 41 mm by 41 mm (1-5/8 inches by 1-5/8 inches), 2.7 mm (No. 12 gage), designed to accept special spring held, hardened steel nuts. Trapeze hangers are not permitted for steam supply and condensate piping.
   1. Allowable hanger load: Manufacturers rating less 91kg (200 pounds).
   2. Guide individual pipes on the horizontal member of every other trapeze hanger with 6 mm (1/4-inch) U-bolt fabricated from steel rod. Provide Type 40 insulation shield, secured by two 13 mm (1/2-inch) galvanized steel bands, or insulated calcium silicate shield for insulated piping at each hanger.

G. Pipe Hangers and Supports: (MSS SP-58), use hangers sized to encircle insulation on insulated piping. Refer to Section 22 07 11 PLUMBING INSULATION for insulation thickness. To protect insulation, provide Type 39 saddles for roller type supports or insulated calcium silicate shields. Provide Type 40 insulation shield or insulated calcium silicate shield at all other types of supports and hangers including those for insulated piping.
   1. General Types (MSS SP-58):
      a. Standard clevis hanger: Type 1; provide locknut.
      b. Riser clamps: Type 8.
      c. Wall brackets: Types 31, 32 or 33.
      d. Roller supports: Type 41, 43, 44 and 46.
      e. Saddle support: Type 36, 37 or 38.
      f. Turnbuckle: Types 13 or 15.
      g. U-bolt clamp: Type 24.
      h. Copper Tube:
         1) Hangers, clamps and other support material in contact with tubing shall be painted with copper colored epoxy paint, plastic coated or taped with isolation tape to prevent electrolysis.
         2) For vertical runs use epoxy painted or plastic coated riser clamps.

3) For supporting tube to strut: Provide epoxy painted pipe straps for copper tube or plastic inserted vibration isolation clamps.
4) Insulated Lines: Provide pre-insulated calcium silicate shields sized for copper tube.

H. Pre-insulated Calcium Silicate Shields:
1. Provide 360 degree water resistant high density 965 kPa (140 psi) compressive strength calcium silicate shields encased in galvanized metal.
2. Pre-insulated calcium silicate shields to be installed at the point of support during erection.
3. Shield thickness shall match the pipe insulation.
4. The type of shield is selected by the temperature of the pipe, the load it must carry, and the type of support it will be used with.
a. Shields for supporting cold water shall have insulation that extends a minimum of one inch past the sheet metal.
b. The insulated calcium silicate shield shall support the maximum allowable water filled span as indicated in MSS-SP 69. To support the load, the shields shall have one or more of the following features: structural inserts 4138 kPa (600 psi) compressive strength, an extra bottom metal shield, or formed structural steel (ASTM A36) wear plates welded to the bottom sheet metal jacket.
5. Shields may be used on steel clevis hanger type supports, roller supports or flat surfaces.

I. Seismic Restraint of Piping: Refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

2.9 PIPE PENETRATIONS

A. Pipe penetration sleeves shall be installed for all pipe other than rectangular blocked out floor openings for risers in mechanical bays.
B. Pipe penetration sleeve materials shall comply with all fire stopping requirements for each penetration.
C. To prevent accidental liquid spills from passing to a lower level, provide the following:

1. For sleeves: Extend sleeve 25 mm (1 inch) above finished floor and provide sealant for watertight joint.
2. For blocked out floor openings: Provide 40 mm (1-1/2 inch) angle set in silicone adhesive around opening.
3. For drilled penetrations: Provide 40 mm (1-1/2 inch) angle ring or square set in silicone adhesive around penetration.

D. Penetrations are not allowed through beams or ribs, but may be installed in concrete beam flanges. Any deviation from these requirements must receive prior approval of COR.

E. Sheet metal, plastic, or moisture resistant fiber sleeves shall be provided for pipe passing through floors, interior walls, and partitions, unless brass or steel pipe sleeves are specifically called for below.

F. Cast iron or zinc coated pipe sleeves shall be provided for pipe passing through exterior walls below grade. The space between the sleeve and pipe shall be made watertight with a modular or link rubber seal. The link seal shall be applied at both ends of the sleeve.

G. Galvanized steel or an alternate black iron pipe with asphalt coating sleeves shall be for pipe passing through concrete beam flanges, except where brass pipe sleeves are called for. A galvanized steel Sleeve shall be provided for pipe passing through floor of mechanical rooms, laundry work rooms, and animal rooms above basement. Except in mechanical rooms, sleeves shall be connected with a floor plate.

H. Brass Pipe Sleeves shall be provided for pipe passing through quarry tile, terrazzo or ceramic tile floors. The sleeve shall be connected with a floor plate.

I. Sleeve clearance through floors, walls, partitions, and beam flanges shall be 25 mm (1 inch) greater in diameter than external diameter of pipe. Sleeve for pipe with insulation shall be large enough to accommodate the insulation plus 25 mm (1 inch) in diameter. Interior openings shall be caulked tight with fire stopping material and sealant to prevent the spread of fire, smoke, and gases.

J. Sealant and Adhesives: Shall be as specified in Section 07 92 00, JOINT SEALANTS.

2.10 TOOLS AND LUBRICANTS

A. Furnish, and turn over to the COR, special tools not readily available commercially, that are required for disassembly or adjustment of equipment and machinery furnished.

B. Grease Guns with Attachments for Applicable Fittings: One for each type of grease required for each motor or other equipment.

C. Tool Containers: metal, permanently identified for intended service and mounted, or located, where directed by the COR.

D. Lubricants: A minimum of 0.95 L (1 quart) of oil, and 0.45 kg (1 pound) of grease, of equipment manufacturer's recommended grade and type, in unopened containers and properly identified as to use for each different application.

2.11 WALL, FLOOR AND CEILING PLATES

A. Material and Type: Chrome plated brass or chrome plated steel, one piece or split type with concealed hinge, with set screw for fastening to pipe, or sleeve. Use plates that fit tight around pipes, cover openings around pipes and cover the entire pipe sleeve projection.

B. Thickness: Not less than 2.4 mm (3/32-inch) for floor plates. For wall and ceiling plates, not less than 0.64 mm (0.025-inch) for up to 80 mm (3 inch) pipe, 0.89 mm (0.035-inch) for larger pipe.

C. Locations: Use where pipe penetrates floors, walls and ceilings in exposed locations, in finished areas only. Wall plates shall be used where insulation ends on exposed water supply pipe drop from overhead. A watertight joint shall be provided in spaces where brass or steel pipe sleeves are specified.

2.12 ASBESTOS

A. Materials containing asbestos are not permitted.

PART 3 - EXECUTION

3.1 ARRANGEMENT AND INSTALLATION OF EQUIPMENT AND PIPING

A. Location of piping, sleeves, inserts, hangers, and equipment, access provisions shall be coordinated with the work of all trades. Piping, sleeves, inserts, hangers, and equipment shall be located clear of windows, doors, openings, light outlets, and other services and utilities. Equipment layout drawings shall be prepared to coordinate proper location and personnel access of all facilities. The drawings shall be submitted for review.

B. Manufacturer's published recommendations shall be followed for installation methods not otherwise specified.

C. Operating Personnel Access and Observation Provisions: All equipment and systems shall be arranged to provide clear view and easy access, without use of portable ladders, for maintenance and operation of all devices including, but not limited to: all equipment items, valves, filters, strainers, transmitters, sensors, control devices. All gages and indicators shall be clearly visible by personnel standing on the floor or on permanent platforms. Maintenance and operating space and access provisions that are shown on the drawings shall not be changed nor reduced.

1. Provide access panels where required to meet access requirements.
    a. Access panels shall be conform to requirements of architectural specifications.

D. Structural systems necessary for pipe and equipment support shall be coordinated to permit proper installation.

E. Location of pipe sleeves, trenches and chases shall be accurately coordinated with equipment and piping locations.

F. Cutting Holes:

1. Holes through concrete and masonry shall be cut by rotary core drill. Pneumatic hammer, impact electric, and hand or manual hammer type drill will not be allowed, except as permitted by COR where working area space is limited.

2. Holes shall be located to avoid interference with structural members such as beams or grade beams. Holes shall be laid out in advance and drilling done only after approval by COR. If the Contractor considers it necessary to drill through structural members, this matter shall be referred to COR for approval.
3. Waterproof membrane shall not be penetrated. Pipe floor penetration block outs shall be provided outside the extents of the waterproof membrane.

G. Minor Piping: Generally, small diameter pipe runs from drips and drains, water cooling, and other service are not shown but must be provided.

H. Protection and Cleaning:
1. Equipment and materials shall be carefully handled, properly stored, and adequately protected to prevent damage before and during installation, in accordance with the manufacturer's recommendations and as approved by the COR. Damaged or defective items in the opinion of the COR, shall be replaced.
2. Protect all finished parts of equipment, such as shafts and bearings where accessible, from rust prior to operation by means of protective grease coating and wrapping. Close pipe openings with caps or plugs during installation. Pipe openings, equipment, and plumbing fixtures shall be tightly covered against dirt or mechanical injury. At completion of all work thoroughly clean fixtures, exposed materials and equipment.

I. Concrete and Grout: Concrete and shrink compensating grout 25 MPa (3000 psi) minimum shall be used for all pad or floor mounted equipment.
1. Refer to Section 03 30 00, CAST-IN-PLACE CONCRETE for concrete requirements.

J. Gages, thermometers, valves and other devices shall be installed with due regard for ease in reading or operating and maintaining said devices. Thermometers and gages shall be located and positioned to be easily read by operator or staff standing on floor or walkway provided. Servicing shall not require dismantling adjacent equipment or pipe work.

K. Work in Existing Building:
   1. Perform as specified in Article, OPERATIONS AND STORAGE AREAS, Article, ALTERATIONS, and Article, RESTORATION of the Section 01 00 00, GENERAL REQUIREMENTS for relocation of existing equipment, alterations and restoration of existing building(s).
   2. As specified in Section 01 00 00, GENERAL REQUIREMENTS, Article, OPERATIONS AND STORAGE AREAS, make alterations to existing service piping at times that will cause the least interfere with normal operation of the facility.

L. Work in bathrooms, restrooms, housekeeping closets: All pipe penetrations behind escutcheons shall be sealed with plumbers putty.

M. Switchgear & Data Equipment Drip Protection: Every effort shall be made to eliminate the installation of pipe above electrical and telephone switchgear, or data equipment. If this is not possible, encase pipe in a second pipe with a minimum of joints.
   1. Provide drain valve and drain piping from low point of casement pipe. Route drain to nearest accessible floor drain or similar approved indirect drain location.
   2. Drain piping shall be 1" (minimum).

N. Inaccessible Equipment:
   1. Where the Government determines that the Contractor has installed equipment not conveniently accessible for operation and maintenance, equipment shall be removed and reinstalled or remedial action performed as directed at no additional cost to the Government.
   2. The term "conveniently accessible" is defined as capable of being reached without the use of ladders, or without climbing or crawling under or over obstacles such as motors, fans, pumps, belt guards, transformers, high voltage lines, piping, and ductwork.
      a. Equipment installed in or above ceilings, such as strainers, valves, and pumps, etc., shall be considered "conveniently accessible" provided that suitable ceiling access is provided by access panels and/or easily removable ceiling tiles, and that access is not blocked by other piping, ductwork, wiring, equipment, structural members, or other building components.

3.2 TEMPORARY PIPING AND EQUIPMENT

A. Continuity of operation of existing facilities may require temporary installation or relocation of equipment and piping. Temporary equipment or pipe installation or relocation shall be provided to maintain continuity of operation of existing facilities.

B. The Contractor shall provide all required facilities in accordance with the requirements of phased construction and maintenance of service. All piping and equipment shall be properly supported, sloped to drain, operate without excessive stress, and shall be insulated where injury can occur to personnel by contact with operating facilities. The requirements of Paragraph 3.1 shall apply.

C. Temporary facilities and piping shall be completely removed and any openings in structures sealed. Necessary blind flanges and caps shall be provided to seal open piping remaining in service.

3.3 RIGGING

A. Openings in building structures shall be planned to accommodate design scheme.

B. Alternative methods of equipment delivery may be offered and will be considered by Government under specified restrictions of phasing and service requirements as well as structural integrity of the building.

C. All openings in the building shall be closed when not required for rigging operations to maintain proper environment in the facility for Government operation and maintenance of service.

D. Contractor shall provide all facilities required to deliver specified equipment and place on foundations. Attachments to structures for rigging purposes and support of equipment on structures shall be Contractor's full responsibility.

E. Contractor shall check all clearances, weight limitations and shall provide a rigging plan designed by a Registered Professional Engineer. All modifications to structures, including reinforcement thereof, shall be at Contractor's cost, time and responsibility.

F. Rigging plan and methods shall be referred to COR for evaluation prior to actual work.

3.4 PIPE AND EQUIPMENT SUPPORTS

A. Where hanger spacing does not correspond with joist or rib spacing, use structural steel channels secured directly to joist and rib structure that will correspond to the required hanger spacing, and then suspend the equipment and piping from the channels. Holes shall be drilled or burned in structural steel ONLY with the prior written approval of the COR.

B. The use of chain pipe supports, wire or strap hangers, wood for blocking, stays and bracing, or hangers suspended from piping above shall not be permitted. Rusty products shall be replaced.

C. Hanger rods shall be used that are straight and vertical. Turnbuckles for vertical adjustments may be omitted where limited space prevents use. A minimum of 15 mm (1/2-inch) clearance between pipe or piping covering and adjacent work shall be provided.

D. For horizontal and vertical plumbing pipe supports, refer to the International Plumbing Code (IPC), latest edition, and these specifications.

E. Paint all fabricated metal support materials.

F. Overhead Supports:

1. The basic structural system of the building is designed to sustain the loads imposed by equipment and piping to be supported overhead.
2. Provide steel structural members, in addition to those shown, of adequate capability to support the imposed loads, located in accordance with the final approved layout of equipment and piping.
3. Tubing and capillary systems shall be supported in channel troughs.

G. Floor Supports:

1. Provide concrete bases, concrete anchor blocks and pedestals, and structural steel systems for support of equipment and piping. Concrete bases and structural systems shall be anchored and doweled to resist forces under operating and seismic conditions (if applicable) without excessive displacement or structural failure.

2. Bases and supports shall not be located and installed until equipment mounted thereon has been accepted. Bases shall be sized to match equipment mounted thereon plus 50 mm (2 inch) excess on all edges. Structural drawings shall be reviewed for additional requirements. Bases shall be neatly finished and smoothed, shall have chamfered edges at the top, and shall be suitable for painting.
3. All equipment shall be shimmed, leveled, firmly anchored, and grouted with epoxy grout. Anchor bolts shall be placed in sleeves, anchored to the bases. Fill the annular space between sleeves and bolts with a grout material to permit alignment and realignment.
4. For seismic anchoring, refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

3.5 LUBRICATION

A. All equipment and devices requiring lubrication shall be lubricated prior to initial operation. All devices and equipment shall be field checked for proper lubrication.
B. All devices and equipment shall be equipped with required lubrication fittings. A minimum of one liter (one quart) of oil and 0.5 kg (one pound) of grease of manufacturer's recommended grade and type for each different application shall be provided. All materials shall be delivered to COR in unopened containers that are properly identified as to application.
C. A separate grease gun with attachments for applicable fittings shall be provided for each type of grease applied.
D. All lubrication points shall be accessible without disassembling equipment, except to remove access plates.

3.6 PLUMBING SYSTEMS DEMOLITION

A. Rigging access, other than indicated on the drawings, shall be provided after approval for structural integrity by the COR. Such access shall be provided without additional cost or time to the Government. Where work is in an operating plant, approved protection from dust and debris shall be provided at all times for the safety of plant personnel and maintenance of plant operation and environment of the plant.

B. Unless specified otherwise, all piping, wiring, conduit, and other devices associated with the equipment not re-used in the new work shall be completely removed from Government property per Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT. This includes all concrete equipment pads, pipe, valves, fittings, insulation, and all hangers including the top connection and any fastenings to building structural systems. All openings shall be sealed after removal of equipment, pipes, ducts, and other penetrations in roof, walls, floors, in an approved manner and in accordance with plans and specifications where specifically covered. Structural integrity of the building system shall be maintained. Reference shall also be made to the drawings and specifications of the other disciplines in the project for additional facilities to be demolished or handled.

C. All valves including gate, globe, ball, butterfly, check, backflow prevention, and pressure reducing, all pressure gages and thermometers with wells shall remain Government property and shall be removed and delivered to COR and stored as directed. The Contractor shall remove all other material and equipment, devices and demolition debris under these plans and specifications. Such material shall be removed from Government property expeditiously and shall not be allowed to accumulate.

3.7 JOB CONDITIONS - WORK IN EXISTING BUILDING

A. Building Operation: Government employees will be continuously operating and managing all facilities, including temporary facilities, that serve the medical center.

B. Maintenance of Service: Schedule all work to permit continuous service as required by the medical center.

C. Phasing of Work: Comply with all requirements shown on drawings or specified.

D. Building Working Environment: Maintain the architectural and structural integrity of the building and the working environment at all times. Maintain the interior of building at 18 degrees C (65 degrees F) minimum. Limit the opening of doors, windows or other access openings to brief periods as necessary for rigging purposes. No storm water or ground water leakage permitted. Provide daily clean-up of construction and demolition debris on all floor surfaces and on all equipment being operated by VA.

E. Acceptance of Work for Government Operation: As new facilities are made available for operation and these facilities are of beneficial use to the Government, inspections will be made and tests will be performed. Based on the inspections, a list of contract deficiencies will be issued to the Contractor. After correction of deficiencies as necessary for beneficial use, the Contracting Officer will process necessary acceptance and the equipment will then be under the control and operation of Government personnel.

F. Alterations to existing service piping shall be made at times that will cause the least interference with normal operation of the facility.

3.8 UTILITY SERVICE INTERRUPTIONS

A. No utility service such as water, gas, steam, sewer, electricity, fire protection systems, or communication systems may be interrupted without prior approval of COR.

B. Limited utility service interruptions, as required for interconnections of new and existing systems, will be permitted by the COR during periods when the demands are not critical to the operation of the medical center. These non-critical periods are limited to between 8 p.m. and 5 a.m. in the appropriate off-season (if applicable). Provide at least one week advance notice to the COR.

C. For utility outages projected to last less than 8 hours, provide at least 7 days advance notice to the COR.

D. For utility outages projected to last more than 8 hours, provide at least 14 days advance notice to the COR.

3.9 CLEANING

A. All work areas shall be maintained in a clean and workmanlike manner throughout the construction period.

B. All debris, dust, and construction waste shall be removed from the work area at the close of each work day and disposed of at an approved location.

C. Piping systems shall be flushed, blown or pigged as necessary to deliver clean systems.

D. At completion of all work thoroughly clean fixtures, exposed materials and equipment.

E. The interior of all tanks shall be cleaned prior to delivery and beneficial use by the Government. All piping shall be tested in accordance with the specifications and the International Plumbing Code (IPC), latest edition. All filters, strainers, fixture faucets shall be flushed of debris prior to final acceptance.

F. Contractor shall be fully responsible for all costs, damage, and delay arising from failure to provide clean systems.

3.10 PAINTING

A. Prior to final inspection and acceptance of the work areas and facilities for beneficial use by the Government, the work areas, facilities, equipment, and systems modified or added under this contract shall be thoroughly cleaned and painted.

B. In addition, the following special conditions apply:

1. Cleaning shall be thorough. Solvents, cleaning materials and methods recommended by the manufacturers shall be used for the specific tasks. All rust shall be removed prior to painting and from surfaces to remain unpainted. Scratches, scuffs, and abrasions shall be repaired prior to applying prime and finish coats.

2. The following Material And Equipment shall NOT be painted::

a. Motors, controllers, control switches, and safety switches.

b. Control and interlock devices.

c. Regulators.

d. Pressure reducing valves.

e. Control valves and thermostatic elements.

f. Lubrication devices and grease fittings.
g. Copper, brass, aluminum, stainless steel and bronze surfaces.
h. Valve stems and rotating shafts.
i. Pressure gages and thermometers.
j. Glass.
k. Name plates.

3. Control and instrument panels shall be cleaned and damaged surfaces repaired. Touch-up painting shall be made with matching paint obtained from manufacturer or computer matched.
4. Pumps, motors, steel and cast iron bases, and coupling guards shall be cleaned, and shall be touched-up with the same color as utilized by the pump manufacturer
5. Temporary Facilities: Apply paint to surfaces that do not have existing finish coats.

3.11 IDENTIFICATION SIGNS

A. Laminated plastic signs, with engraved lettering not less than 5 mm (3/16-inch) high, shall be provided that designates equipment function, for all equipment, switches, motor controllers, relays, meters, control devices, including automatic control valves. Nomenclature and identification symbols shall correspond to that used in maintenance manual, and in diagrams specified elsewhere. Attach by chain, adhesive, or screws.
B. Factory Built Equipment: Metal plate, securely attached, with name and address of manufacturer, serial number, model number, size, performance shall be placed on factory built equipment.
C. Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.
D. Install tags with corrosion resistant chain.
E. Pipe Identification:
   1. Identify service, flow direction, and pressure.
   2. Install in clear view and align with axis of piping.

3. Locate identification not to exceed 20 feet on straight runs including risers and drops, adjacent to each valve and Tee, at each side of penetration of structure or enclosure, and at each obstruction.

F. Coordination with Existing Identification:
1. Final identification of piping, valves, equipment, and accessories shall match the existing identification scheme used in the facility. Identification scheme shall be approved by the COR.

3.12 TEMPORARY OPERATION

A. Temporary use of equipment is specified in Section 01 00 00, GENERAL REQUIREMENTS, Article, TEMPORARY USE OF MECHANICAL AND ELECTRICAL EQUIPMENT.

3.13 OPERATING AND PERFORMANCE TESTS

A. Prior to the final inspection, all required tests shall be performed as specified in Section 01 00 00, GENERAL REQUIREMENTS, Article, TESTS and Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS. submit the test reports and records to the COR.
B. Should evidence of malfunction in any tested system, or piece of equipment or component part thereof, occur during or as a result of tests, make proper corrections, repairs or replacements, and repeat tests at no additional cost to the Government.
C. When completion of certain work or system occurs at a time when final control settings and adjustments cannot be properly made to make performance tests, then make performance tests such systems respectively during first actual seasonal use of respective systems following completion of work.

3.14 OPERATION AND MAINTENANCE MANUALS

A. Provide four bound copies. The Operations and maintenance manuals shall be delivered to COR not less than 30 days prior to completion of a phase or final inspection.
B. Provide one digital copy in PDF format. The Operations and maintenance manuals shall be delivered to COR not less than 30 days prior to completion of a phase or final inspection.

C. All new and temporary equipment and all elements of each assembly shall be included.
D. Data sheet on each device listing model, size, capacity, pressure, speed, horsepower, impeller size, and other information shall be included.
E. Manufacturer’s installation, maintenance, repair, and operation instructions for each device shall be included. Assembly drawings and parts lists shall also be included. A summary of operating precautions and reasons for precautions shall be included in the Operations and Maintenance Manual.
F. Lubrication instructions, type and quantity of lubricant shall be included.
G. Schematic diagrams and wiring diagrams of all control systems corrected to include all field modifications shall be included.
H. Set points of all interlock devices shall be listed.
I. Trouble-shooting guide for the control system troubleshooting guide shall be inserted into the Operations and Maintenance Manual.
J. Emergency procedures.

3.15 STARTUP AND TESTING

A. Perform tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.
B. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.

3.16 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.
B. Components provided under this section of the specification will be tested as part of a larger system.

3.17 DEMONSTRATION AND TRAINING

A. Refer to individual specification sections for training required to be provided for each specific system.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

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SECTION 22 05 12
GENERAL MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION:

A. This section describes the general motor requirements for plumbing equipment.

1.2 RELATED WORK:

A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.3 SUBMITTALS:

A. In accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, submit the following:

B. Shop Drawings:

1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
2. Motor nameplate information shall be submitted including electrical ratings, dimensions, mounting details, materials, horsepower, power factor, current as a function of speed, current efficiency, speed as a function of load, RPM, enclosure, starting characteristics, torque characteristics, code letter, full load and locked rotor current, service factor, and lubrication method.
3. Motor parameters required for the determination of the Reed Critical Frequency of vertical hollow shaft motors shall be submitted.

C. Manuals:

1. Companion copies of complete maintenance and operating manuals, including technical data sheets and application data shall be submitted simultaneously with the shop drawings.

D. Certification: Two weeks prior to final inspection, unless otherwise noted, four copies of the following certification shall be submitted to the Resident Engineer:

1. Certification shall be submitted stating that the motors have been properly applied, installed, adjusted, lubricated, and tested.

1.4 PUBLICATIONS:

A. The publications listed below (including amendments, addenda, revisions, supplements and errata) shall form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

B. National Electrical Manufacturers Association (NEMA):

1. MG 1-07 Motors and Generators.
2. MG 2-01 Safety Standard and Guide for Selection, Installation and Use of Electric Motors and Generators.

C. National Fire Protection Association (NFPA):

1. 70-2020 National Electrical Code (NEC).

PART 2 - PRODUCTS

2.1 MOTORS:

A. For alternating current, fractional and integral horsepower motors, NEMA Publications MG 1 and MG 2 shall apply.

B. Voltage ratings shall be as follows:

1. Single phase:
   a. Motors connected to 120-volt systems: 115 volts.
   b. Motors connected to 208-volt systems: 200 volts.
   c. Motors connected to 240 volt or 480 volt systems: 230/460 volts, dual connection.
2. Three phase:
   a. Motors connected to 208-volt systems: 200 volts.
   b. Motors, less than 74.6 kW (100 HP), connected to 240 volt or 480 volt systems: 230/460 volts, dual connection.
   c. Motors, 74.6 kW (100 HP) or larger, connected to 240-volt systems: 230 volts.
   d. Motors, 74.6 kW (100 HP) or larger, connected to 480-volt systems: 460 volts.
   e. Motors connected to high voltage systems: Shall conform to NEMA Standards for connection to the nominal system voltage shown on the drawings.

C. Number of phases shall be as follows:

1. Motors, less than 373 W (1/2 HP): Single phase.

2. Motors, 373 W (1/2 HP) and larger: 3 phase.
3. Exceptions:
    a. Hermetically sealed motors.
    b. Motors for equipment assemblies, less than 746 W (1 HP), may be single phase provided the manufacturer of the proposed assemblies cannot supply the assemblies with three phase motors.

D. Horsepower ratings shall be adequate for operating the connected loads continuously in the prevailing ambient temperatures in areas where the motors are installed, without exceeding the NEMA standard temperature rises for the motor insulation.

E. Motor designs, as indicated by the NEMA code letters, shall be coordinated with the connected loads to assure adequate starting and running torque.

F. Motor Enclosures:
1. Shall be the NEMA types shown on the drawings for the motors.
2. Where the types of motor enclosures are not shown on the drawings, they shall be the NEMA types, which are most suitable for the environmental conditions where the motors are being installed.
3. Enclosures shall be primed and finish coated at the factory with manufacturer's prime coat and standard finish.
4. All motors in hazardous locations shall be approved for the application and meet the Class and Group as required by the area classification.

G. Electrical Design Requirements
1. Motors shall be continuous duty.
2. The insulation system shall be rated minimum of class B, 130° C (266° F).
3. The maximum temperature rise by resistance at rated power shall not exceed Class B limits, 80° C (176° F).
4. The speed/torque and speed/current characteristics shall comply with NEMA Design A or B, as specified.
5. Motors shall be suitable for full voltage starting, unless otherwise noted.

6. Motors for variable frequency drive applications shall adhere to NEMA standards publication MG 1, Part 30, Application considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable voltage or Adjustable frequency controls, or both, or Part 31, Definite Purpose Inverter Fed Polyphase Motors.

H. Mechanical Design Requirements

1. Bearings shall be rated for a minimum of 26,280 hours L-10 life at full load direct coupled, except vertical high thrust motors.
2. Vertical motors shall be capable of withstanding a momentary up thrust of at least 30% of normal down thrust.
3. Grease lubricated bearings shall be designed for electric motor use. Grease shall be capable of the temperatures associated with electric motors and shall be compatible with Polyurea based greases.
4. Grease fittings, if provided, shall be Alemite type or equivalent.
5. Oil lubricated bearings, when specified, shall have an externally visible sight glass to view oil level.
6. Vibration shall not exceed 0.15 inch per second, unfiltered peak.
7. Noise level shall meet the requirements of the application.
8. Motors on 180 frames and larger shall have provisions for lifting eyes or lugs capable of a safety factor of 5.
9. All external fasteners shall be corrosion resistant.
10. Condensation heaters, when specified, shall keep motor windings at least 5° C (41° F) above ambient temperature.
11. Winding thermostats, when specified shall be normally closed, connected in series.
12. Grounding provisions shall be in the main terminal box.

I. Additional requirements for specific motors, as indicated in other sections, shall also apply.

J. NEMA Premium Efficiency Electric Motors, Motor Efficiencies: All permanently wired polyphase motors of 746 Watts (1 Horsepower) or more shall meet the minimum full-load efficiencies as indicated in the following table, and as specified in this specification. Motors of 746 Watts (one horsepower) or more with open, drip-proof or totally enclosed fan-cooled enclosures shall be NEMA premium efficiency type, unless otherwise indicated. Motors provided as an integral part of motor driven equipment are excluded from this requirement if a minimum seasonal or overall efficiency requirement is indicated for that equipment by the provisions of another section.

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K. Minimum Power Factor at Full Load and Rated Voltage: 90 percent at 1200 RPM, 1800 RPM and 3600 RPM. Power factor correction capacitors shall be installed unless the motor is controlled by a variable frequency drive. The power factor correction capacitors shall be able to withstand high voltage transients and power line variations without breakdown.

L. Energy Efficiency of Small Motors (Motor Efficiencies): All motors under 746 W (1 hp) shall meet the requirements of the DOE Small Motor Regulation.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. Install motors in accordance with manufacturer’s recommendations, the NEC, NEMA, as shown on the drawings and/or as required by other sections of these specifications.

3.2 FIELD TESTS

A. Megger all motors after installation, before start-up. All shall test free from grounds.

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SECTION 22 05 19
METERS AND GAGES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section describes the requirements for water meters and pressure gages.

1.2 RELATED WORK

A. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

1.3 SUBMITTALS

A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.

B. Manufacturer's Literature and Data:
   1. Water Meter.
   2. Pressure Gages.
   3. Product certificates for each type of meter and gauge.

C. Operations and Maintenance manual shall include:
   1. System Description.
   2. Major assembly block diagrams.
   3. Troubleshooting and preventive maintenance guidelines.
   4. Spare parts information.

D. Shop Drawings shall include the following:
   1. One line, wiring and terminal diagrams including terminals identified, protocol or communication modules, and Ethernet connections.

1.4 APPLICABLE PUBLICATIONS

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

B. American National Standards Institute (ANSI):
   1. B40.1-05 Gauges-Pressure Indicating Dial Type-Elastic

C. American Society of Mechanical Engineers (ASME):
   1. B40.1-05 Gauges-Pressure Indicating Dial Type-Elastic

D. American Water Works Association (AWWA):

1. C700-07 (R 2003) Standard for Cold Water Meters, Displacement Type, Bronze Main Case
2. C701-07 Cold Water Meters-Turbine Type, for Customer Service AWWA/ ANSI
3. C702-01 Cold water meters – Compound Type

E. International Code Council (ICC):
IPC-2021 International Plumbing Code

1.5 AS-BUILT DOCUMENTATION

A. The electronic documentation and copies of the Operations and Maintenance Manual, approved submittals, shop drawings, and other closeout documentation shall be prepared by a computer software program complying with Section 508 of the Rehabilitation Act of 1973, as amended (29 U.S.C 794d). The manufacturer or vendor of the software used to prepare the electronic documentation shall have a Voluntary Product Accessibility Template made available for review and included as part of the Operations and Maintenance Manual or closeout documentation. All available accessibility functions listed in the Voluntary Accessibility Template shall be enabled in the prepared electronic files. As Adobe Acrobat is a common industry format for such documentation, following the document, "Creating Accessible Adobe PDF files, A Guide for Document Authors" that is maintained and made available by Adobe free of charge is recommended.”

B. Four sets of manufacturer’s literature and data updated to include submittal review comments and any equipment substitutions.

C. Four sets of operation and maintenance data updated to include submittal review comments shall be inserted into a three ring binder. All aspects of system operation and maintenance procedures, including piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices such as damper and door closure interlocks shall be included. A List of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.

PART 2 – PRODUCTS

2.1 DISPLACEMENT WATER METER

A. For pipe sizes under 50 mm (2 inches), the water meter shall be displacement type, full size nutating disc, magnetic drive, sealed register, and fully conform to AWWA C700. Peak domestic flow shall be 2.2 L/S (34 gpm). The meter register shall indicate flow in liters (U.S. gallons).

B. The water meter shall be rated for use at temperatures ranging from -40° C (-40° F) and +70° C (158° F) and operate at a working pressure of 1034 kPa (150-psig).

C. The meter case, bottom caps, and register box lids shall be constructed from cast bronze.

2.2 WATER METER STRAINER

A. All meters sizes 50 mm or DN50 (2 inches) and above, shall be fitted with a bronze inlet strainer with top access. The strainer shall conform to AWWA 702.

2.3 PRESSURE GAGES FOR WATER AND SEWAGE USAGE

A. ANSI B40.1 all metal case 114 mm (4-1/2 inches) diameter, bottom connected throughout, graduated as required for service, and identity labeled. Range shall be 0 to 1375 kPa (0 to 200 psi) gauge.

B. The pressure element assembly shall be bourdon tube. The mechanical movement shall be lined to pressure element and connected to pointer.
C. The dial shall be non-reflective aluminum with permanently etched scale markings graduated in kPa and psi.
D. The pointer shall be dark colored metal.
E. The window shall be glass.
F. The ring shall be brass or stainless steel.
G. The accuracy shall be grade A, plus or minus 1 percent of middle half of scale range.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Direct mounted pressure gages shall be installed in piping tees with pressure gage located on pipe at the most readable position.
B. Valves and snubbers shall be installed in piping for each pressure gage.
C. Pressure gages shall be installed where indicated on the drawings and at the following locations:
    1. Inlet and outlet of each pressure reducing valve
    2. Suction and discharge of each domestic water pump or re-circulating hot water return pump.
        a. Single gages may be used where the gage is piped to both the suction and discharge side of the pump and isolation valves are provided for each side.
D. Water meter installation shall conform to AWWA C700, AWWA C701, and AWWA C702.

3.2 FIELD QUALITY CONTROL

A. The meter assembly shall be visually inspected and operationally tested. The correct multiplier placement on the face of the meter shall be verified.

3.3 COMMISSIONING

A. Provide commissioning documentation accordance with the requirements of Section 22 08 00, COMMISSIONING FOR PLUMBING SYSTEMS.

B. Components provided under this section of the specification will be tested as part of a larger system.

3.4 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer' s technical representative for one hour to instruct VA Personnel in operation and maintenance of the system.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

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SECTION 22 05 23
GENERAL-DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section describes the requirements for general-duty valves for domestic water and sewer systems.

1.2 RELATED WORK

A. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.
B. Section 22 11 00, FACILITY WATER DISTRIBUTION.
C. Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.

1.3 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Where conflicts occur these specifications and the VHA standard will govern.
B. American Society of Sanitary Engineering (ASSE):
   1. 1001-2017 Performance Requirements for Atmospheric Type Vacuum Breakers
   2. 1003-2009 Performance Requirements for Water Pressure Reducing Valves for Domestic Water Distribution Systems
   3. 1011-2017 Performance Requirements for Hose Connection Vacuum Breakers
   4. 1013-2011 Performance Requirements for Reduced Pressure Principle Backflow Preventers and Reduced Pressure Principle Fire Protection Backflow Preventers
   5. 1015-2011 Performance Requirements for Double Check Backflow Prevention Assemblies and Double Check Fire Protection Backflow Prevention Assemblies
   6. 1017-2009 Performance Requirements for Temperature Actuated Mixing Valves for Hot Water Distribution Systems
   7. 1020-2004 Performance Requirements for Pressure Vacuum Breaker Assembly
   8. 1035-2008 Performance Requirements for Laboratory Faucet Backflow Preventers

9. 1069-2005 Performance Requirements for Automatic Temperature Control Mixing Valves
10. 1070-2015 Performance Requirements for Water Temperature Limiting Devices
11. 1071-2012 Performance Requirements for Temperature Actuated Mixing Valves for Plumbed Emergency Equipment

C. American Society for Testing and Materials (ASTM):
1. A126-2019 Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
2. A276/A276M-2017 Standard Specification for Stainless Steel Bars and Shapes
3. A536-2019 Standard Specification for Ductile Iron Castings
4. B62-2017 Standard Specification for Composition Bronze or Ounce Metal Castings
5. B584-2014 Standard Specification for Copper Alloy Sand Castings for General Applications

D. International Code Council (ICC):
1. IPC-2021 International Plumbing Code

E. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS):
1. SP-25-2018 Standard Marking Systems for Valves, Fittings, Flanges and Unions
2. SP-67-2017 Butterfly Valves
3. SP-70-2011 Gray Iron Gate Valves, Flanged and Threaded Ends
4. SP-71-2018 Gray Iron Swing Check Valves, Flanged and Threaded Ends
5. SP-80-2019 Bronze Gate, Globe, Angle, and Check Valves
6. SP-85-2011 Gray Iron Globe & Angle Valves, Flanged and Threaded Ends
7. SP-110-2010 Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends

F. National Environmental Balancing Bureau (NEBB):
1. Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems, 8th Edition 2015

G. NSF International (NSF):
1. 61-2019 Drinking Water System Components - Health Effects

2. 372-2016 Drinking Water System Components - Lead Content

H. University of Southern California Foundation for Cross Connection Control and Hydraulic Research (USC FCCCHR):

1. Manual of Cross-Connection Control, 10th Edition

1.4 SUBMITTALS

A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 22 05 23, GENERAL-DUTY VALVES FOR PLUMBING PIPING", with applicable paragraph identification.

C. Manufacturer's Literature and Data Including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.

1. Ball Valves.
2. Butterfly Valves.
3. Balancing Valves.
4. Check Valves.
5. Backflow Preventers.
6. Thermostatic Mixing Valves.
7. Pressure Reducing Valves

D. Test and Balance reports for balancing valves.

E. Complete operating and maintenance manuals including, technical data sheets and information for ordering replaceable parts:

1. Include complete list indicating all components of the systems.
2. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.
3. Piping diagrams of thermostatic mixing valves to be installed.

F. Completed System Readiness Checklist provided by the Commissioning Agent and completed by the Contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

G. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Valves shall be prepared for shipping as follows:
   1. Protect internal parts against rust and corrosion.
   2. Protect threads, flange faces, grooves, and weld ends.
   3. Set ball and plug valves open to minimize exposure of functional surfaces
   4. Set butterfly valves closed or slightly open.
   5. Block check valves in either closed or open position.

B. Valves shall be prepared for storage as follows:
   1. Maintain valve end protection.
   2. Store valves indoors and maintain at higher than ambient dew point temperature.

1.6 AS BUILT DOCUMENTATION

A. Comply with requirements in Paragraph “AS-BUILT DOCUMENTATION” of Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

PART 2 - PRODUCTS

2.1 VALVES, GENERAL

A. Asbestos packing and gaskets are prohibited.

B. Bronze valves shall be made with dezincification resistant materials. Bronze valves made with copper alloy (brass) containing greater than 15 percent zinc shall not be permitted.

C. Valves in insulated piping shall have 50 mm or DN50 (2 inch) stem extensions and extended handles of non-thermal conductive material that allows operating the valve without breaking the vapor seal or disturbing the insulation. Memory stops shall be fully adjustable after insulation is applied.

D. All valves used to supply potable water shall meet the requirements of NSF 61 and NSF 372.

E. Bio-Based Materials: For products designated by the USDA' s bio-based Bio-Preferred Program, provide products that meet or exceed USDA recommendations for bio-based content, so long as products meet all performance requirements in this specifications section. For more information regarding the product categories covered by the Bio-Preferred Program, visit http://www.biopreferred.gov.

2.2 SHUT-OFF VALVES

A. Cold, Hot, Re-circulating Hot, Tempered, and Re-circulating Tempered Water:

1. 50 mm or DN50 (2 inches) and smaller: Ball, MSS SP-110, Ball valve shall be full port three piece or two piece with a union design with adjustable stem package. Threaded stem designs are not allowed. The ball valve shall have a SWP rating of 1035 kPa (150 psig) and a CWP rating of 4138 kPa (600 psig). The body material shall be Bronze ASTM B584, Alloy C844. The ends shall be non-lead solder.
2. Less than 100 mm DN100 (4 inches): Butterfly shall have an iron body with EPDM seal and aluminum bronze disc. The butterfly valve shall meet MSS SP-67, type I standard. The butterfly valve shall have a SWP rating of 1380 kPa (200 psig). The valve design shall be lug type suitable for bidirectional dead-end service at rated pressure. The body material shall meet ASTM A536, ductile iron.

2.3 MANUAL BALANCING VALVES

A. Hot Water Re-circulating, 75 mm or DN75 (3 inches) and smaller manual balancing valve shall be of bronze body, brass ball construction with glass and carbon filled TFE seat rings and designed for positive shutoff. The manual balancing valve shall have differential pressure read-out ports across the valve seat area. The read out ports shall be fitted with internal EPT inserts and check valves. The valve body shall have 8 mm or DN8 NPT (1/4 inch NPT) tapped drain and purge port. The valves shall have memory stops that allow the valve to close for service and then reopened to set point without disturbing the balance position. All valves shall have calibrated nameplates to assure specific valve settings.

B. Greater than 75 mm or DN75 (3 inches): Manual balancing valves shall be of heavy duty cast iron flanged construction with 861 kPa (125 psig) flange connections. The flanged manual balancing valves shall have either a brass ball with glass and carbon filled TFE seal rings or fitted with a bronze seat, replaceable bronze disc with EPDM seal insert and stainless steel stem. The design pressure shall be 1200 kPa (175 psig) at 121 degrees C (250 degrees F).

2.4 CHECK VALVES

A. Check valves less than 80 mm or DN80 (3 inches) and smaller) shall be class 125, bronze swing check valves with non metallic Buna-N disc. The check valve shall meet MSS SP-80 Type 4 standard. The check valve shall have a CWP rating of 1380 kPa (200 psig). The check valve shall have a Y pattern horizontal body design with bronze body material conforming to ASTM B 62, solder joints, and PTFE or TFE disc.

2.5 WATER PRESSURE REDUCING VALVE AND CONNECTIONS

A. 80 mm or DN80 (3 inches) or smaller: The pressure reducing valve shall consist of a bronze body and bell housing, a separate access cover for the plunger, and a bolt to adjust the downstream pressure. The bronze bell housing and access cap shall be threaded to the body and shall not require the use of ferrous screws. The assembly shall be of the balanced piston design and shall reduce pressure in both flow and no flow conditions. The assembly shall be accessible for maintenance without having to remove the body from the line.

B. The regulator shall have a tap for pressure gauge.

C. Setting: Entering water pressure, discharge pressure, capacity, size, and related measurements shall be as shown on the drawings.

D. Connections Valves and Strainers: shut off valves shall be installed on each side of reducing valve and a bypass line equal in size to the regulator inlet pipe shall be installed with a normally closed globe valve. A strainer shall be installed on inlet side of, and same size as pressure reducing valve. A pressure gage shall be installed on the low pressure side of the line.

2.6 BACKFLOW PREVENTERS

A. A backflow prevention assembly shall be installed at any point in the plumbing system where the potable water supply comes in contact with a potential source of contamination. The backflow prevention assembly shall be ASSE 1013 listed and certified.

B. Reduced pressure backflow preventers shall be installed in the following applications.

1. Water make up to heating systems, chilled water systems, computer room air conditioners, and similar equipment consuming water.

C. The reduced pressure principle backflow prevention assembly shall be ASSE listed 1013 with full port OS&Y gate valves and an integral relief monitor switch. The main body and access cover shall be epoxy coated duct iron conforming to ASTM A536 grade 4. The seat ring and check valve shall be Noryl (NSF listed). The stem shall be stainless steel conforming to ASTM A276. The seat disc elastomer shall be EPDM. The checks and the relief valve shall be accessible for maintenance without removing the device from the line. An epoxy coated wye type strainer with flanged connections shall be installed on the inlet.

2.7 THERMOSTATIC MIXING VALVES

A. Thermostatic Mixing Valves shall comply with the following general performance requirements:

1. Shall meet ASSE requirements for water temperature control.
2. The body shall be cast bronze or brass with corrosion resistant internal parts preventing scale and biofilm build-up. Provide chrome-plated finish in exposed areas.
3. No special tool shall be required for temperature adjustment, maintenance, replacing parts and disinfecting operations.
4. Valve shall be able to be placed in various positions without making temperature adjustment or reading difficult.
5. Valve finish shall be chrome plated in exposed areas.
6. Valve shall allow easy temperature adjustments to allow hot water circulation. Internal parts shall be able to withstand disinfecting operations of chemical and thermal treatment of water temperatures up to 82°C (180°F) for 30 minutes or 50 mg/L (50 ppm) chlorine residual concentration for 24 hours.

7. Parts shall be easily removed or replaced without dismantling the valves, for easy scale removal and disinfecting of parts.
8. Valve shall have a manual adjustable temperature control with locking mechanism to prevent tampering by end user. Outlet temperature shall be visible to ensure outlet temperature does not exceed specified limits, particularly after thermal eradication procedures.
9. Provide mixing valves with integral check valves with screens and stop valves.

B. Water Temperature Limiting Devices:
1. Application: Single plumbing fixture point-of-use such as sinks or lavatories.
2. Standard: ASSE 1070.
3. Pressure Rating: 861 kPa (125 psig).
4. Type: Thermostatically controlled water mixing valve set at 43 degrees C (110 degrees F).
5. Connections: Threaded union, compression or soldered inlets and outlet.
6. Upon cold water supply failure the hot water flow shall automatically be reduced to 0.2 gpm maximum.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Valve interior shall be examined for cleanliness, freedom from foreign matter, and corrosion. Special packing materials shall be removed, such as blocks, used to prevent disc movement during shipping and handling.
B. Valves shall be operated in positions from fully open to fully closed. Guides and seats shall be examined and made accessible by such operations.
C. Threads on valve and mating pipe shall be examined for form and cleanliness.

D. Mating flange faces shall be examined for conditions that might cause leakage. Bolting shall be checked for proper size, length, and material. Gaskets shall be verified for proper size and that its material composition is suitable for service and free from defects and damage.
E. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
B. Valves shall be located for easy access and shall be provide with separate support. Valves shall be accessible with access doors when installed inside partitions or above hard ceilings.
C. Valves shall be installed in horizontal piping with stem at or above center of pipe
D. Valves shall be installed in a position to allow full stem movement.
E. Check valves shall be installed for proper direction of flow and as follows:
   1. Swing Check Valves: In horizontal position with hinge pin level.
F. Install temperature-actuated water mixing valves with check stops or shutoff valves on inlets.
   1. Install thermometers at discharge of each mixing valve.
G. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no cost to the Government.
H. Install thermostatic balancing valves with inlet strainer and inlet and outlet isolation valves.

3.3 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:
   1. Calibrated balancing valves.
   2. Master, thermostatic, water mixing valves.
   3. Manifold, thermostatic, water-mixing-valve assemblies.
B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit.

3.4 ADJUSTING

A. Valve packing shall be adjusted or replaced after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves shall be replaced if persistent leaking occurs.

B. Set field-adjustable flow set points of balancing valves and record data. Ensure recorded data represents actual measured or observed conditions. Permanently mark settings of valves and other adjustment devices allowing settings to be restored. Set and lock memory stops. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.

C. Set field-adjustable temperature set points of temperature-actuated water mixing valves.

D. Testing and adjusting of balancing valves shall be performed by an independent NEBB Accredited Test and Balance Contractor. A final settings and flow report shall be submitted to the COR.

1. Refer to Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.

E. Setpoints

1. Thermostatic mixing valves (point of use): 105 F discharge temperature.
2. Thermostatic mixing valves (emergency fixture use): 85 F discharge temperature.
3. Balancing valves (hot water recirculation): 126 F recirculating temperature.

3.5 STARTUP AND TESTING

A. Perform tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.

B. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.

C. The CxA will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the COR and CxA. Provide a minimum notice of 10 working days prior to startup and testing.

3.6 \B COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

B. Components provided under this section of the specification will be tested as part of a larger system.

3.7 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer' s technical representative for one hour to instruct each VA Personnel responsible in operation and maintenance of the system.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

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SECTION 22 05 33
HEAT TRACING FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section describes the requirement for supplying, installing, and testing of the electric heat tracing system of the plumbing piping. Freeze protection shall be utilized for domestic water piping in areas subject to freezing temperatures. Ice and snow melting shall be utilized for gutters, downspouts, roof drain bodies and roof drain leaders exposed to snow and ice accumulation.

B. A complete listing of all acronyms and abbreviations are included in Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

C. Section 01 81 11, SUSTAINABLE CONSTRUCTION REQUIREMENTS.

D. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

E. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

F. Section 22 07 11, PLUMBING INSULATION.

G. Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

H. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

I. Section 26 05 19, LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES.

1.3 APPLICABLE PUBLICATIONS

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

B. The Institute of Electrical and Electronic Engineers (IEEE):

1. 515.1-2012 Standard for the Testing, Design, Installation, and Maintenance of Electrical Resistance Trace Heating for Commercial Applications

C. International Code Council, (ICC):

1. IPC-2021 International Plumbing Code

D. National Fire Protection Association (NFPA):

1. 70- 2020 National Electrical Code (NEC)

E. Underwriters' Laboratories, Inc. (UL):
   1. 508-2018 Standard For Industrial Control Equipment

1.4 SUBMITTALS

A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.

B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 22 05 33, HEAT TRACING FOR PLUMBING PIPING", with applicable paragraph identification.

C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.
   1. Rated capacity.
   2. Length of cable.
   3. Cable spacing.
   4. Electrical power requirements.
   5. Controls.
   6. Enclosures.
   7. Accessories.
   8. The shop drawings shall include plans, sections, details, wiring diagrams, and attachments to other work. The wiring diagrams shall include power, signal, and control wiring.
   9. Field quality control test reports shall be submitted.
   10. Operation and Maintenance data in accordance with section 1.6.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: Ten years' experience in design, engineering, manufacture and support of specified system and components.

B. Product Requirements:
   1. Pipe tracing cable assembly shall be factory assembled, immersed in water for a minimum of 12 hours, and then tested for insulation resistance, high potential breakdown and continuity before leaving the factory.

2. Factory Mutual approved heating cable that has the same wattage per lineal foot (power output), throughout its entire length.
3. UL Listed, thermostat and contactor panel.
4. UL Listed Control/Monitor Panel.
5. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.6 AS-BUILT DOCUMENTATION

A. Refer to Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

PART 2 - PRODUCTS

2.1 PLASTIC INSULATED SERIES RESISTANCE HEATING CABLES

A. The plastic insulated series resistance heating cables shall comply with IEEE 515.1.
B. The heating element shall be a single or dual strained resistor wire. Terminations shall be made with waterproof, factory assembled non heating leads with connectors at both ends.
C. The electrical insulated jacket shall be a minimum 0.10 mm (4.0 mil) polymeric with silicone jacket, ETFE or polyolefin. The cable cover shall be aluminum braid and silicone or Hylar outer jacket.
D. The maximum operating temperature shall be 150 degrees C (302 degrees F).
E. Maximum exposure temperature shall be 85 degrees C (185 degrees F).

2.2 CONTROLS

A. Pipe mounting thermostats for Freeze protection shall have be a remote bulb unit with adjustable temperature range from minus 1 to 10 degrees C (30 to 50 degrees F). The thermostat shall be snap action, open-on-rise, single pole switch with minimum current rating adequate for the connected cable. The thermostat shall be remote bulb on capillary, resistance temperature device, or thermistor for direct sensing of pipe wall temperature.
B. DDC Integration
   1. Heat trace systems shall be monitored by the DDC system.

2. Relays, current transformers, and other devices necessary for monitoring of heat trace systems by DDC shall be provided by DDC contractor.
3. Refer to Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

C. All heat trace circuits shall be fed from a 30mA Equipment Protective Device (EPD) type circuit breaker and provided with a pilot-lit switch/disconnecting means that illuminates when the heat trace circuit is activated.
1. Refer to the electrical specifications and drawings for additional requirements.

2.3 ACCESSORIES

A. Cable Installation Accessories: Fiberglass tape, heat-conductive putty, cable ties, silicone end seals and splice kits, and installation clips all furnished by manufacturer, or as recommended in writing by manufacturer.
B. Warning Labels: Shall comply with NFPA 70.
C. Warning Tape: Continuously printed "Electrical Tracing"; vinyl, at least 0.08 mm (3 mils) thick, and with pressure-sensitive, permanent, waterproof, self-adhesive back.
1. Width for Markers on Pipes with Outside Dimension, Including Insulation, Less Than 150 mm (6 inches): 19 mm (3/4 inch) minimum.
2. Width for Markers on Pipes with Outside Dimension, Including Insulation, 150 mm (6 inches) or Larger: 38 mm (1-1/2 inches) minimum.

PART 3 - EXECUTION

3.1 GENERAL

A. Inspect surfaces and substrates of electric heating cables for compliance with requirements of this specification. Ensure surfaces and pipes in contact with electric heating cables are free of burrs and sharp protrusions.
B. Notify COR if the existing substrate conditions are unsuitable for application of heating cables in accordance with manufacturer' s recommendations.

C. If the installation of the heat tracing is unsatisfactory, then the Contractor shall correct the installation at no cost to the Government.

3.2 INSTALLATION

A. Electric heating cable shall be installed for the following applications:
   1. Snow and ice melting for roof drain bodies, overflow roof drain bodies, roof drain leaders, overflow roof drain leaders, and roof drain overflow outlets: Plastic-insulated series-resistance heating cable.
   2. Freeze protection of plumbing piping: Plastic-insulated series-resistance heating cable.

B. Electric heating cable shall be installed across expansion, construction, and control joints according to the manufacturer’s recommendations using cable protection conduit and slack cable to allow for movement without damage to cable.

C. The installation of electric heating cable for snow and ice melting on roofs, gutters and downspouts, and roof drain leaders shall be provided with clips furnished by the manufacturer that are compatible with roof, gutters and downspouts and roof drain leaders.

D. Electric heating cable for pipe freeze protection shall be installed according to the following:
   1. Electric heating cables shall be installed after piping has been tested and before insulation is installed.
   2. Electric heat cables shall be installed according to IEEE 515.1
   3. Insulation shall be installed or applied over piping with electric cables. Refer to Section 22 07 11, PLUMBING INSULATION.
   4. Warning tape shall be installed on pipe insulation where piping is equipped with electric heating cables.

E. Field adjustable switches and circuit breaker trip ranges shall be set.

F. Heating cables including leads shall be protected from damage.

G. Equipment shall be grounded according to Section 26 05 19, LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES.

H. Wiring shall be connected according to Section 26 05 19, LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES.

3.3 TESTS

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform tests after cable installation but before application of coverings such as insulation, wall or ceiling construction, or concrete.
2. Test cables for electrical continuity and insulation integrity before energizing.
3. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.

C. Repeat tests for continuity, insulation resistance, and input power after applying thermal insulation on pipe-mounted cables.

D. If deficiency is found, Contractor shall correct all deficiencies at no cost to the Government.

E. Prepare test and inspection reports.

3.4 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

B. Components provided under this section of the specification will be tested as part of a larger system.

3.5 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer' s technical representative for one hour to instruct VA Personnel in operation and maintenance of the system.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

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SECTION 22 07 11
PLUMBING INSULATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. Field applied insulation for thermal efficiency and condensation control for
   1. Plumbing piping and equipment.

B. Definitions
   1. ASJ: All service jacket, white finish facing or jacket.
   2. Air conditioned space: Space having air temperature and/or humidity controlled by mechanical equipment.
   3. Cold: Equipment or piping handling media at design temperature of 16 degrees C (60 degrees F) or below.
   4. Concealed: Piping above ceilings and in chases, shafts, interstitial spaces, and pipe spaces.
   5. Exposed: Piping and equipment exposed to view in finished areas including mechanical equipment rooms or exposed to outdoor weather. Areas such as chases, shafts, interstitial spaces, pipe spaces, unfinished attics, crawl spaces, and pipe basements are not considered finished areas.
   6. FSK: Foil-scrim-kraft facing.
   7. Hot: Plumbing equipment or piping handling media above 41 degrees C (105 degrees F).
   8. Density: kg/m3 - kilograms per cubic meter (Pcf - pounds per cubic foot).
   9. Thermal conductance: Heat flow rate through materials.
      a. Flat surface: Watts per square meter (BTU per hour per square foot).
      b. Pipe or Cylinder: Watts per square meter (BTU per hour per linear foot).
   10. Thermal Conductivity (k): Watt per meter, per degree C (BTU per inch thickness, per hour, per square foot, per degree F temperature difference).

11. Vapor Retarder (Vapor Barrier): A material which retards the transmission (migration) of water vapor. Performance of the vapor retarder is rated in terms of permeance (perms). For the purpose of this specification, vapor retarders shall have a maximum published permeance of 0.1 perms and vapor barriers shall have a maximum published permeance of 0.001 perms.
12. CW: Cold water.
13. HW: Hot water.
14. HWC: Hot water circulation.
15. PVDC: Polyvinylidene chloride vapor retarder jacketing, white.

1.2 RELATED WORK

A. Section 07 84 00, JOINT FIRESTOPPING.
B. Section 07 84 13, PENETRATION FIRESTOPPING.
C. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.
D. Section 22 05 23, GENERAL-DUTY VALVES FOR PLUMBING PIPING.
E. Section 22 11 00, FACILITY WATER DISTRIBUTION.
F. Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

1.3 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by basic designation only.
B. Federal Specifications (Fed. Spec.):
   1. L-P-535-201 Plastic Sheet (Sheeting): Plastic Strip; Poly (Vinyl Chloride) and Poly (Vinyl Chloride - Vinyl Acetate), Rigid.
C. Military Specifications (Mil. Spec.):
   1. MIL-A-3316C-1987 Adhesives, Fire-Resistant, Thermal Insulation
   2. MIL-A-24179A (1)-87 Adhesive, Flexible Unicellular-Plastic Thermal Insulation
   3. MIL-C-19565C (1)-88 Coating Compounds, Thermal Insulation, Fire- and Thermal Insulation
D. American Society for Testing and Materials (ASTM):
   1. C177-2019 Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded -Hot-Plate Apparatus

2. C411-2019 Standard test method for Hot-Surface Performance of High-Temperature Thermal Insulation
3. C449-2019 Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement
4. C518-2021 Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus
5. C534-2020 Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
6. C585-2016 Standard Practice for Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System) R (1998)
7. C1136-2021 Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation
8. E84-2021 Standard Test Method for Surface Burning Characteristics of Building Materials
9. E119-2020 Standard Test Method for Fire Tests of Building Construction and Materials
10. E136-2019 Standard Test Methods for Behavior of Materials in a Vertical Tube Furnace at 750 degrees C (1380 F)

E. National Fire Protection Association (NFPA):
1. 101-2021 Life Safety Code
2. 251-2006 Standard methods of Tests of Fire Endurance of Building Construction Materials
3. 255-2006 Standard Method of tests of Surface Burning Characteristics of Building Materials

F. Underwriters Laboratories, Inc (UL):
1. 723-2018 Standard for Safety Test for Surface Burning Characteristics of Building Materials

G. Manufacturer’s Standardization Society of the Valve and Fitting Industry (MSS):
1. SP58-2019 Pipe Hangers and Supports Materials, Design, Manufacture, Selection, Application, and Installation

1.4 QUALITY ASSURANCE

A. Refer to article QUALITY ASSURANCE, in Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

B. Criteria:

1. Comply with NFPA 90A, particularly paragraphs 4.3.3.1 through 4.3.3.6, 4.3.10.2.6, and 5.4.6.4, parts of which are quoted as follows:
   a. 4.3.3.1 Pipe insulation and coverings, vapor retarder facings, adhesives, fasteners, tapes, unless otherwise provided for in 4.3.3.1.12 shall have, in the form in which they are used, a maximum flame spread index of 25 without evidence of continued progressive combustion and a maximum smoke developed index of 50 when tested in accordance with NFPA 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.
   b. 4.3.3.1.1 Where these products are to be applied with adhesives, they shall be tested with such adhesives applied, or the adhesives used shall have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when in the final dry state. (See 4.2.4.2).
   c. 4.3.3.3 Pipe insulation and coverings shall not flame, glow, smolder, or smoke when tested in accordance with a similar test for pipe covering, ASTM C 411, Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation, at the temperature to which they are exposed in service.
   d. 4.3.3.3.1 In no case shall the test temperature be below 121°C (250°F).
2. Test methods: ASTM E84, UL 723, or NFPA 255.
3. Specified k factors are at 24 degrees C (75 degrees F) mean temperature unless stated otherwise. Where optional thermal insulation material is used, select thickness to provide thermal conductance no greater than that for the specified material. For pipe, use insulation manufacturer's published heat flow tables. For domestic hot water supply and return, run out insulation and condensation control insulation, no thickness adjustment need be made.
4. All materials shall be compatible and suitable for service temperature, and shall not contribute to corrosion or otherwise attack surface to which applied in either the wet or dry state.

C. Every package or standard container of insulation or accessories delivered to the job site for use must have a manufacturer's stamp or label giving the name of the manufacturer and description of the material.

1.5 SUBMITTALS

A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Shop Drawings:

1. All information, clearly presented, shall be included to determine compliance with drawings and specifications and ASTM, federal and military specifications.
    a. Insulation materials: Specify each type used and state surface burning characteristics.
    b. Insulation facings and jackets: Each type used.
    c. Insulation accessory materials: Each type used.
    d. Manufacturer's installation and fitting fabrication instructions for flexible unicellular insulation.
    e. Make reference to applicable specification paragraph numbers for coordination.

1.6 \B DELIVERY, STORAGE, AND HANDLING

A. Store materials in clean and dry environment, pipe covering jackets shall be clean and unmarred. Place adhesives in original containers. Maintain ambient temperatures and conditions as required by printed instructions of manufacturers of adhesives, mastics and finishing cements.

1.7 AS-BUILT DOCUMENTATION

A. Comply with requirements in Paragraph '' AS-BUILT DOCUMENTATION'' of Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

PART 2 - PRODUCTS

2.1 MINERAL FIBER OR FIBER GLASS

A. ASTM C612 (Board, Block), Class 1 or 2, density 48 kg/m3 (3 pcf), k = 0.037 (.26) at 24 degrees C (75 degrees F), external insulation for temperatures up to 204 degrees C (400 degrees F).

B. ASTM C553 (Blanket, Flexible) Type I, Class B-3, Density 16 kg/m3 (1 pcf), k = 0.045 (0.31) at 24 degrees C (75 degrees F), for use at temperatures up to 204 degrees C (400 degrees F)
C. ASTM C547 (Pipe Fitting Insulation and Preformed Pipe Insulation), Class 1, with an all service vapor retarder jacket.

2.2 FLEXIBLE ELASTOMERIC CELLULAR THERMAL

A. ASTM C177, C518, flame spread not over 25, smoke developed not over 50, for temperatures from minus 4 degrees C (40 degrees F) to 93 degrees C (200 degrees F).

2.3 INSULATION FACINGS AND JACKETS

A. Vapor Retarder, higher strength with low water permeance = 0.02 or less perm rating, Beach puncture 50 units for insulation facing on pipe insulation jackets. Facings and jackets shall be all service type (ASJ) or PVDC Vapor Retarder jacketing.
B. ASJ jacket shall be white kraft bonded to 0.025 mm (1 mil) thick aluminum foil, fiberglass reinforced, with pressure sensitive adhesive closure. Comply with ASTM C1136. Beach puncture 50 units, Suitable for painting without sizing. Jackets shall have minimum 40 mm (1-1/2 inch) lap on longitudinal joints and minimum 75mm (3 inch) butt strip on end joints. Butt strip material shall be same as the jacket. Lap and butt strips shall be self-sealing type with factory-applied pressure sensitive adhesive.
C. Vapor Retarder medium strength with low water vapor permeance of 0.02 or less perm rating), Beach puncture 25 units: Foil-Scrim-Kraft (FSK) or PVDC vapor retarder jacketing type for concealed ductwork and equipment.

D. Field applied vapor barrier jackets shall be provided, in addition to the specified facings and jackets, on all exterior piping as well as on interior piping, piping in high humidity areas, and piping conveying fluids below ambient temperature. The vapor barrier jacket shall consist of a multi-layer laminated cladding with a maximum water vapor permeance of 0.001 perms. The minimum puncture resistance shall be 35 cm-kg (30 inch-pounds) for interior locations and 92 cm-kg (80 inch-pounds) for exterior or exposed locations or where the insulation is subject to damage.

E. Factory composite materials may be used provided.

F. Pipe fitting insulation covering (jackets): Fitting covering shall be premolded to match shape of fitting and shall be polyvinyl chloride (PVC) conforming to Fed Spec L-P-335, composition A, Type II Grade GU, and Type III, minimum thickness 0.7 mm (0.03 inches). Provide color matching vapor retarder pressure sensitive tape.

2.4 PIPE COVERING PROTECTION SADDLES

A. Cold pipe support: Premolded pipe insulation 180 degrees (half-shells) on bottom half of pipe at supports. Material shall be cellular glass or high density Polyisocyanurate insulation of the same thickness as adjacent insulation. Density of Polyisocyanurate insulation shall be a minimum of 48 kg/m3 (3.0 pcf).

B. Warm or hot pipe supports: Premolded pipe insulation (180 degree half-shells) on bottom half of pipe at supports. Material shall be high density Polyisocyanurate (for temperatures up to 149 degrees C [300 degrees F]), cellular glass or calcium silicate. Insulation at supports shall have same thickness as adjacent insulation. Density of Polyisocyanurate insulation shall be a minimum of 48 kg/m3 (3.0 pcf).

2.5 BADHESIVE, MASTIC, CEMENT

A. Mil. Spec. MIL-A-3316, Class 1: Jacket and lap adhesive and protective finish coating for insulation.

B. Mil. Spec. MIL-A-3316, Class 2: Adhesive for laps and for adhering insulation to metal surfaces.

C. Mil. Spec. MIL-A-24179, Type II Class 1: Adhesive for installing flexible unicellular insulation and for laps and general use.

D. Mil. Spec. MIL-C-19565, Type I: Protective finish for outdoor use.
E. Mil. Spec. MIL-C-19565, Type I or Type II: Vapor barrier compound for indoor use.
F. ASTM C449: Mineral fiber hydraulic-setting thermal insulating and finishing cement.
G. Other: Insulation manufacturers' published recommendations.

2.6 MECHANICAL FASTENERS

A. Pins, anchors: Welded pins, or metal or nylon anchors with galvanized steel or fiber washer, or clips. Pin diameter shall be as recommended by the insulation manufacturer.
B. Staples: Outward clinching galvanized steel
C. Wire: 1.3 mm thick (18 gage) soft annealed galvanized or 1.9 mm (14 gage) copper clad steel or nickel copper alloy.
D. Bands: 13 mm (1/2 inch) nominal width, brass, galvanized steel, aluminum or stainless steel.

2.7 REINFORCEMENT AND FINISHES

A. Tape for Flexible Elastomeric Cellular Insulation: As recommended by the insulation manufacturer.
B. PVC fitting cover: Fed. Spec L-P-535, Composition A, 11-86 Type II, Grade GU, with Form B Mineral Fiber insert, for media temperature 4 degrees C (40 degrees F) to 121 degrees C (250 degrees F). Below 4 degrees C (40 degrees F) and above 121 degrees C (250 degrees F). Provide double layer insert. Provide color matching vapor barrier pressure sensitive tape.

2.8 FIRESTOPPING MATERIAL

A. Other than pipe insulation, refer to Section 07 84 00 FIRESTOPPING.

2.9 FLAME AND SMOKE

A. Unless shown otherwise all assembled systems shall meet flame spread 25 and smoke developed 50 rating as developed under ASTM, NFPA and UL standards and specifications. See paragraph 1.3 "Quality Assurance".

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

A. Required pressure tests of piping joints and connections shall be completed and the work approved by the COR for application of insulation. Surface shall be clean and dry with all foreign materials, such as dirt, oil, loose scale and rust removed.

B. Except for specific exceptions, insulate all specified equipment and piping (pipe, fittings, valves, accessories). Insulate each pipe individually. Do not use scrap pieces of insulation where a full length section will fit.

C. Insulation materials shall be installed in a first class manner with smooth and even surfaces, with jackets and facings drawn tight and smoothly cemented down at all laps. Insulation shall be continuous through all sleeves and openings, except at fire dampers and duct heaters (NFPA 90A). Vapor retarders shall be continuous and uninterrupted throughout systems with operating temperature 16 degrees C (60 degrees F) and below. Lap and seal vapor barrier over ends and exposed edges of insulation. Anchors, supports and other metal projections through insulation on cold surfaces shall be insulated and vapor sealed for a minimum length of 150 mm (6 inches).

D. Install vapor stops at all insulation terminations on either side of valves, pumps and equipment and particularly in straight lengths of pipe insulation.

E. Insulation on hot piping and equipment shall be terminated square at items not to be insulated, access openings and nameplates. Cover all exposed raw insulation with white sealer or jacket material.

F. Plumbing work not to be insulated:
   1. Piping and valves of fire protection system.
   2. Chromium plated brass piping.
   3. Water piping in contact with earth.
   4. Small horizontal cold water branch runs in partitions to individual fixtures may be without insulation for maximum distance of 900 mm (3 feet).

G. Apply insulation materials subject to the manufacturer's recommended temperature limits. Apply adhesives, mastic and coatings at the manufacturer's recommended minimum coverage.

H. Elbows, flanges and other fittings shall be insulated with the same material as is used on the pipe straights. Use of polyurethane spray-foam to fill a PVC elbow jacket is prohibited on cold applications.

I. Firestop Pipe insulation:

1. Provide firestopping insulation at fire and smoke barriers through penetrations. Fire stopping insulation shall be UL listed as defines in Section 07 84 00, FIRESTOPPING.
2. Pipe penetrations requiring fire stop insulation including, but not limited to the following:
   a. Pipe risers through floors
   b. Pipe chase walls and floors
   c. Smoke partitions
   d. Fire partitions

J. Provide vapor barrier jackets over insulation as follows:

1. All interior piping conveying fluids\plain\rtlch\af1\afs22\alang0\ab\ltrch\f1\fs22\lang0\langnp0\langfe0\langfenp0\b piping conveying fluids below ambient temperature.

K. Provide metal jackets over insulation as follows:

1. All plumbing piping exposed to outdoor weather.
2. A 50 mm (2 inch) overlap is required at longitudinal and circumferential joints.

3.2 INSULATION INSTALLATION

A. Molded Mineral Fiber and Fiberglass Pipe and Tubing Covering:

1. Fit insulation to pipe, aligning longitudinal joints. Seal longitudinal joint laps and circumferential butt strips by rubbing hard with a nylon sealing tool to assure a positive seal. Staples may be used to assist in securing insulation. Seal all vapor retarder penetrations on cold piping with a generous application of vapor barrier mastic. Provide inserts and install with metal insulation shields at outside pipe supports. Install freeze protection insulation over heating cable.

2. Contractor's options for fitting, flange and valve insulation:
   a. Insulating and finishing cement for sizes less than 100 mm (4 inches) operating at surface temperature of 16 degrees C (61 degrees F) or more.
   b. Factory premolded, one piece PVC covers with mineral fiber, (Form B), inserts. Provide two insert layers for pipe temperatures below 4 degrees C (40 degrees F), or above 121 degrees C (250 degrees F). Secure first layer of insulation with twine. Seal seam edges with vapor barrier mastic and secure with fitting tape.
   c. Factory molded, ASTM C547 or field mitered sections, joined with adhesive or wired in place. For hot piping finish with a smoothing coat of finishing cement. For cold fittings, 16 degrees C (60 degrees F) or less, vapor seal with a layer of glass fitting tape imbedded between two 2 mm (1/16 inch) coats of vapor barrier mastic.
   d. Fitting tape shall extend over the adjacent pipe insulation and overlap on itself at least 50 mm (2 inches).
3. Nominal thickness in millimeters and inches specified in the schedule at the end of this section.

B. Flexible Elastomeric Cellular Thermal Insulation:
1. Apply insulation and fabricate fittings in accordance with the manufacturer's installation instructions and finish with two coats of weather resistant finish as recommended by the insulation manufacturer.
2. Pipe and tubing insulation:
   a. Use proper size material. Do not stretch or strain insulation.
   b. To avoid undue compression of insulation, provide cork stoppers or wood inserts at supports as recommended by the insulation manufacturer. Insulation shields are specified under Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

c. Where possible, slip insulation over the pipe or tubing prior to connection, and seal the butt joints with adhesive. Where the slip-on technique is not possible, slit the insulation and apply it to the pipe sealing the seam and joints with contact adhesive. Optional tape sealing, as recommended by the manufacturer, may be employed. Make changes from mineral fiber insulation in a straight run of pipe, not at a fitting. Seal joint with tape.

3. Apply sheet insulation to flat or large curved surfaces with 100 percent adhesive coverage. For fittings and large pipe, apply adhesive to seams only.

3.3 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.

B. Components provided under this section of the specification will be tested as part of a larger system. Refer to section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS and related sections for contractor responsibilities for system commissioning.

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SECTION 22 08 00
COMMISSIONING OF PLUMBING SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. The requirements of this Section apply to all sections of Division 22.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

1.3 SUMMARY

A. This Section includes requirements for commissioning plumbing systems, subsystems and equipment. This Section supplements the general requirements specified in Section 01 91 00 General Commissioning Requirements.

B. Refer to Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS for more specifics regarding processes and procedures as well as roles and responsibilities for all Commissioning Team members.

1.4 DEFINITIONS

A. Refer to Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS for definitions.

1.5 COMMISSIONED SYSTEMS

A. Commissioning of a system or systems specified in Division 22 is part of the construction process. Documentation and testing of these systems, as well as training of the VA’s Operation and Maintenance personnel in accordance with the requirements of Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS and of Division 22, is required in cooperation with the VA and the Commissioning Agent.

B. The Plumbing systems commissioning will include the systems listed in Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

C. The Plumbing systems commissioning will include the following systems:

1. Domestic water distribution systems.
2. Water heating systems.
3. Hot water recirculation systems.

4. Backflow preventers.

1.6 SUBMITTALS

A. The commissioning process requires review of selected Submittals. The Commissioning Agent will provide a list of submittals that will be reviewed by the Commissioning Agent. This list will be reviewed and approved by the VA prior to forwarding to the Contractor. Refer to Section 01 33 23 SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES for further details.

B. The commissioning process requires Submittal review simultaneously with engineering review. Specific submittal requirements related to the commissioning process are specified in Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 CONSTRUCTION INSPECTIONS

A. Commissioning of the Building Plumbing Systems will require inspection of individual elements of the Plumbing construction throughout the construction period. The Contractor shall coordinate with the Commissioning Agent in accordance with Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS and the Commissioning Plan to schedule inspections as required to support the commissioning process.

3.2 PRE-FUNCTIONAL CHECKLISTS

A. The Contractor shall complete Pre-Functional Checklists to verify systems, subsystems, and equipment installation is complete and systems are ready for Systems Functional Performance Testing. The Commissioning Agent will prepare Pre-Functional Checklists to be used to document equipment installation. The Contractor shall complete the checklists. Completed checklists shall be submitted to the VA and to the Commissioning Agent for review. The Commissioning Agent may spot check a sample of completed checklists. If the Commissioning Agent determines that the information provided on the checklist is not accurate, the Commissioning Agent will return the marked-up checklist to the Contractor for correction and resubmission. If the Commissioning Agent determines that a significant number of completed checklists for similar equipment are not accurate, the Commissioning Agent will select a broader sample of checklists for review. If the Commissioning Agent determines that a significant number of the broader sample of checklists is also inaccurate, all the checklists for the type of equipment will be returned to the Contractor for correction and resubmission. Refer to SECTION 01 91 00, GENERAL COMMISSIONING REQUIREMENTS for submittal requirements for Pre-Functional Checklists, Equipment Startup Reports, and other commissioning documents.

3.3 CONTRACTORS TESTS

A. Contractor tests as required by other sections of Division 22 shall be scheduled and documented in accordance with Section 01 00 00, GENERAL REQUIREMENTS. All testing shall be incorporated into the project schedule. Contractor shall provide no less than 7 calendar days' notice of testing. The Commissioning Agent will witness selected Contractor tests at the sole discretion of the Commissioning Agent. Contractor tests shall be completed prior to scheduling Systems Functional Performance Testing.

3.4 SYSTEMS FUNCTIONAL PERFORMANCE TESTING:

A. The Commissioning Process includes Systems Functional Performance Testing that is intended to test systems functional performance under steady state conditions, to test system reaction to changes in operating conditions, and system performance under emergency conditions. The Commissioning Agent will prepare detailed Systems Functional Performance Test procedures for review and approval by the COR. The Contractor shall review and comment on the tests prior to approval. The Contractor shall provide the required labor, materials, and test equipment identified in the test procedure to perform the tests. The Commissioning Agent will witness and document the testing. The Contractor shall sign the test reports to verify tests were performed.

1. Refer to Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS, for additional details.

3.5 TRAINING OF VA PERSONNEL

A. Training of the VA operation and maintenance personnel is required in cooperation with the COR and Commissioning Agent. Provide competent, factory-authorized personnel to provide instruction to operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. Contractor shall submit training agendas and trainer resumes in accordance with the requirements of Division 1 specifications. The instruction shall be scheduled in coordination with the COR after submission and approval of formal training plans. Refer to Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS and Division 22 Sections for additional Contractor training requirements.

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SECTION 22 11 00
FACILITY WATER DISTRIBUTION

PART 1 - GENERAL

1.1 DESCRIPTION

A. Domestic water systems, including piping, equipment and all necessary accessories as designated in this section.

B. A complete listing of all acronyms and abbreviations are included in Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

D. Section 07 84 00, JOINT FIRESTOPPING.

E. Section 07 84 13, PENETRATION FIRESTOPPING.

F. Section 07 92 00, JOINT SEALANTS.

G. Section 09 91 24, INTERIOR PAINTING.

H. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

I. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

J. Section 22 07 11, PLUMBING INSULATION.

K. Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

L. Section 31 20 11, EARTHWORK.

1.3 SUBMITTALS

A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Information and material submitted under this section shall be marked “SUBMITTED UNDER SECTION 22 11 00, FACILITY WATER DISTRIBUTIONS”, with applicable paragraph identification.

C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.

1. All items listed in Part 2 - Products.

D. Complete operating and maintenance manuals including wiring diagrams, technical data sheets and information for ordering replacement parts:
   1. Include complete list indicating all components of the systems.
   2. Include complete diagrams of the internal wiring for each item of equipment.
   3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

E. Completed System Readiness Checklist provided by the CxA and completed by the Contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

F. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

G. Piping sterilization plan, including all sterilization materials & procedures as well as isolation of all new piping work from other building piping systems to prevent backflow to other areas of the building during the sterilization process.

H. Shop drawings for all double containment piping systems shall be submitted and shall include details of pipe fabrications (including supporting devices, method of attachment, spacing, etc.), prefabricated double containment fitting dimensions, starting and terminating connections, high-point vent and low-point drain details for the secondary containment, valves and accessories. Submit joint details, methods and location of supports and all other pertinent technical data for all piping to be furnished. Vent & drain locations shall be shown. Leak detection points and equipment shall be shown on shop drawings.

1.4 APPLICABLE PUBLICATIONS

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

B. American Society of Mechanical Engineers (ASME):
   1. A13.1-2013 Scheme for Identification of Piping Systems
   2. B16.3-2011 Malleable Iron Threaded Fittings: Classes 150 and 300

3. B16.9-2012 Factory-Made Wrought Buttwelding Fittings
4. B16.11-2011 Forged Fittings, Socket-Welding and Threaded
5. B16.12-2014 Cast Iron Threaded Drainage Fittings
6. B16.15-2013 Cast Copper Alloy Threaded Fittings: Classes 125 and 250
7. B16.18-2012 Cast Copper Alloy Solder Joint Pressure Fittings
8. B16.22-2013 Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings
9. B16.24-2011 Cast Copper Alloy Pipe Flanges and Flanged Fittings: Classes 150, 300, 600, 900, 1500, and 2500
10. BPVC Section IX-2015 ASME Boiler and Pressure Vessel Code - Welding, Brazing, and Fusing Qualifications

C. American Society of Sanitary Engineers (ASSE):
1. 1010-2004 Performance Requirements for Water Hammer Arresters

D. American Society for Testing and Materials (ASTM):
1. A47/A47M-2014 Standard Specification for Ferritic Malleable Iron Castings
2. A53/A53M-2012 Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
3. A183-2014 Standard Specification for Carbon Steel Track Bolts and Nuts
4. A269/A269M-2014e1 Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service
5. A312/A312M-2015 Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
6. A403/A403M-2014 Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings
7. A536-2014 Standard Specification for Ductile Iron Castings
8. A733-2013 Standard Specification for Welded and Seamless Carbon Steel and Austenitic Stainless Steel Pipe Nipples
9. B32-2014 Standard Specification for Solder Metal
10. B43-2014 Standard Specification for Seamless Red Brass Pipe, Standard Sizes
11. B61-2013 Standard Specification for Steam or Valve Bronze Castings

12. B62-2009 Standard Specification for Composition Bronze or Ounce Metal Castings
13. B75/B75M-2011 Standard Specification for Seamless Copper Tube
14. B88-2014 Standard Specification for Seamless Copper Water Tube
15. B584-2014 Standard Specification for Copper Alloy Sand Castings for General Applications
16. B687-2011 Standard Specification for Brass, Copper, and Chromium-Plated Pipe Nipples
17. C919-2012 Standard Practice for Use of Sealants in Acoustical Applications
18. D1785-2012 Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
19. D2000-2012 Standard Classification System for Rubber Products in Automotive Applications
20. D2564-2012 Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems
21. D2657-2007 Standard Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings
22. D2855-2010 Standard Practice for Making Solvent-Cemented Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings
23. D4101-2014 Standard Specification for Polypropylene Injection and Extrusion Materials
24. E1120-2008 Standard Specification for Liquid Chlorine
25. E1229-2008 Standard Specification for Calcium Hypochlorite
26. F2389-2010 Standard Specification for Pressure-rated Polypropylene (PP) Piping Systems
27. F2620-2013 Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings
28. F2769-2014 Standard Specification for Polyethylene of Raised Temperature (PE-RT) Plastic Hot and Cold-Water Tubing and Distribution Systems

E. American Water Works Association (AWWA):
1. C110-2012 Ductile-Iron and Gray-Iron Fittings
2. C151-2009 Ductile Iron Pipe, Centrifugally Cast
3. C153-2011 Ductile-Iron Compact Fittings

4. C203-2008 Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot Applied
5. C213-2007 Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines
6. C651-2014 Disinfecting Water Mains

F. American Welding Society (AWS):
1. A5.8M/A5.8-2011-AMD1 Specification for Filler Metals for Brazing and Braze Welding

G. International Code Council (ICC):
1. IPC-2021 International Plumbing Code

H. Manufacturers Specification Society (MSS):
1. SP-58-2009 Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation
2. SP-72-2010a Ball Valves with Flanged or Butt-Welding Ends for General Service
3. SP-110-2010 Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends

I. NSF International (NSF):
1. 14-2015 Plastics Piping System Components and Related Materials
2. 61-2014a Drinking Water System Components - Health Effects
3. 372-2011 Drinking Water System Components - Lead Content

J. Plumbing and Drainage Institute (PDI):
1. PDI-WH 201-2010 Water Hammer Arrestors

K. Department of Veterans Affairs:
1. H-18-8-2013 Seismic Design Handbook
2. H-18-10 Plumbing Design Manual

1.5 QUALITY ASSURANCE

A. A certificate shall be submitted prior to welding of steel piping showing the Welder’s certification. The certificate shall be current and no more than one year old. Welder’s qualifications shall be in accordance with ASME BPVC Section IX.

B. All grooved joint couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be by the same manufacturer as the groove components.

C. All pipe, couplings, fittings, and specialties shall bear the identification of the manufacturer and any markings required by the applicable referenced standards.

D. Bio-Based Materials: For products designated by the USDA's Bio-Preferred Program, provide products that meet or exceed USDA recommendations for bio-based content, so long as products meet all performance requirements in this specifications section. For more information regarding the product categories covered by the Bio-Preferred Program, visit http://www.biopreferred.gov.

PART 2 - PRODUCTS

2.1 MATERIALS

A. 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 or NSF 372. Endpoint devices used to dispense water for drinking must meet the requirements of NSF/ANSI 61, Section 9.

2.2 UNDERGROUND WATER SERVICE CONNECTIONS TO BUILDINGS

A. From inside face of exterior wall to a distance of approximately 5 feet (1500 mm) outside of building and underground inside building, material to be the same for the size specified inside of the building.

B. Three inches (75 mm) Diameter and Over: Ductile iron, AWWA C151, 125 psi (850 kPa) water steam pressure (WSP), exterior bituminous coating, and cement lined. Provide flanged and anchored connection to interior piping.

C. Under 3 inch (75 mm) Diameter: Copper tubing, ASTM B88, Type K, seamless, annealed. Fittings as specified under Article 2.2, INTERIOR DOMESTIC WATER PIPING. Use brazing alloys, AWS A5.8, Classification BCuP.

D. Flexible Expansion Joint: Ductile iron with ball joints rated for 250 psi (1725 kPa) working pressure conforming to ANSI/AWWA C153/A21.53, capable of deflecting a minimum of 20 degrees in each direction and expanding simultaneously to the amount shown on the drawings. Flexible expansion joint size shall match the pipe size it is connected to and shall have the expansion capability designed as an integral part of the ductile iron ball castings. Pressure containing parts shall be lined with a minimum of 15 mils of fusion bonded epoxy conforming to the applicable requirements of ANSI/AWWA C213 and shall be factory tested with a 1500 volt spark test. Flexible expansion joint shall have flanged connections conforming to ANSI/AWWA C110. Bolts and nuts shall be 316 stainless steel and gaskets shall be neoprene. The flexible expansion fitting shall not expand or exert an axial thrust under internal water pressure. Provide piping joint restraints at each mechanical joint end connection and piping restraints at the penetration of the building wall. The restraints shall be provided to address the developed trust at the change of piping direction.

2.3 ABOVE GROUND (INTERIOR) WATER PIPING

A. Pipe: Copper tube, ASTM B88, Type L, drawn.

B. Fittings for Copper Tube:

1. Wrought copper or bronze castings conforming to ANSI B16.18 and B16.22. Unions shall be bronze, MSS SP72 & SP 110, Solder or braze joints. Use 95/5 tin and antimony for all soldered joints.
2. Mechanical press-connect fittings for copper pipe and tube are prohibited. See Plumbing Design Manual for additional information.

C. Adapters: Provide adapters for joining screwed pipe to copper tubing.

D. Solder: ASTM B32 Composition Sb5 HA or HB. Provide non-corrosive flux.

E. Brazing alloy: AWS A5.8, Classification BCuP.

2.4 EXPOSED WATER PIPING

A. Finished Room: Use full iron pipe size chrome plated brass piping for exposed water piping connecting fixtures, casework, cabinets, equipment and reagent racks when not concealed by apron including those furnished by the Government or specified in other sections.

1. Pipe: Fed. Spec. WW-P-351, standard weight.

2. Fittings: ANSI B16.15 cast bronze threaded fittings with chrome finish.
3. Nipples: ASTM B 687, Chromium-plated.
4. Unions: Mss SP-72, SP-110, Brass or Bronze with chrome finish. Unions 2-1/2 inches (65 mm) and larger shall be flange type with approved gaskets.

B. Unfinished Rooms, Mechanical Rooms, Electrical Rooms, IDF Rooms, and similar spaces: Chrome-plated brass piping is not required.
1. Paint piping systems as specified in Section 09 91 24, INTERIOR PAINTING.

2.5 TRAP PRIMER WATER PIPING:

A. Pipe: Copper tube, ASTM B88, type K, hard drawn.
B. Fittings: Bronze castings conforming to ANSI B16.18 Solder joints.
C. Solder: ASTM B32 composition Sb5. Provide non-corrosive flux.

2.6 STRAINERS

A. Provide on high pressure side of pressure reducing valves, on suction side of pumps, on inlet side of indicating and control instruments and equipment subject to sediment damage and where shown on drawings. Strainer element shall be removable without disconnection of piping.
B. Water: Basket or "Y" type with easily removable cover and brass strainer basket.
C. Body: Smaller than 3 inches (80 mm), brass or bronze; 3 inches (80 mm) and larger, cast iron or semi-steel.

2.7 DIELECTRIC FITTINGS

A. Provide dielectric couplings or unions between ferrous and non-ferrous pipe.

2.8 STERILIZATION CHEMICALS

A. Hypochlorite: ASTM E1120-08
B. Liquid Chlorine: ASTM E1229-08

2.9 WATER HAMMER ARRESTER:

A. Closed copper tube chamber with permanently sealed 60 psig (410 KpA) air charge above a Double O-ring piston. Two high heat Buna-N 0-rings pressure packed and lubricated with FDA approved silicone compound. All units shall be designed in accordance with ASSE 1010 for sealed wall installations without an access panel. Size and install in accordance with Plumbing and Drainage Institute requirements (PDI-WH 201). Provide water hammer arrestors at:
   1. All solenoid valves.
   2. All groups of two or more flush valves.
   3. All quick opening or closing valves.
   4. All medical washing equipment.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General: Comply with the International Plumbing Code and the following:
   1. Install branch piping for water from the piping system and connect to all fixtures, valves, cocks, outlets, casework, cabinets and equipment, including those furnished by the Government or specified in other sections.
   2. Pipe shall be round and straight. Cutting shall be done with proper tools. Pipe, except for plastic and glass, shall be reamed to full size after cutting.
   3. All pipe runs shall be laid out to avoid interference with other work.
   4. Install union and shut-off valve on pressure piping at connections to equipment.
   5. Pipe Hangers, Supports and Accessories:
      a. All piping shall be supported per the International Plumbing Code.

b. Shop Painting and Plating: Hangers, supports, rods, inserts and accessories used for pipe supports shall be shop coated with red lead or zinc chromate primer paint. Electroplated copper hanger rods, hangers and accessories may be used with copper tubing.

c. Floor, Wall and Ceiling Plates, Supports, Hangers:
   1) Solid or split un-plated cast iron.
   2) All plates shall be provided with set screws.
   3) Pipe Hangers: Height adjustable clevis type.
   4) Adjustable Floor Rests and Base Flanges: Steel.
   5) Concrete Inserts: "Universal" or continuous slotted type.
   6) Hanger Rods: Mild, low carbon steel, fully threaded or Threaded at each end with two removable nuts at each end for positioning rod and hanger and locking each in place.
   7) Riser Clamps: Malleable iron or steel.
   8) Rollers: Cast iron.
   9) Self-drilling type expansion shields shall be "Phillips" type, with case hardened steel expander plugs.
   10) Hangers and supports utilized with insulated pipe and tubing shall have 180 degree (min.) metal protection shield Centered on and welded to the hanger and support. The shield shall be 4 inches in length and be 16 gauge steel. The shield shall be sized for the insulation.
   11) Miscellaneous Materials: As specified, required, directed or as noted on the drawings for proper installation of hangers, supports and accessories. If the vertical distance exceeds 6 m (20 feet) for cast iron pipe additional support shall be provided in the center of that span. Provide all necessary auxiliary steel to provide that support.
   12) With the installation of each flexible expansion joint, provide piping restraints for the upstream and downstream section of the piping at the flexible expansion joint. Provide calculations supporting the restraint length design and type of selected restraints.

6. Install chrome plated cast brass escutcheon with set screw at each wall, floor and ceiling penetration in exposed finished locations and within cabinets and millwork.
7. Penetrations:
   a. Fire Stopping: Where pipes pass through fire partitions, fire walls, smoke partitions, or floors, install a fire stop that provides an effective barrier against the spread of fire, smoke and gases as specified in Section 07 84 00. Completely fill and seal clearances between raceways and openings with the fire stopping materials.
   b. Waterproofing: At floor penetrations, completely seal clearances around the pipe and make watertight with sealant as specified in Section 07 92 00.

B. Domestic Water piping shall conform to the following:
1. Grade all lines to facilitate drainage. Provide drain valves at bottom of risers and all low points in system. Design domestic hot and cold water circulating lines with no traps.
2. Connect branch lines at bottom of main serving fixtures below and pitch down so that main may be drained through fixture. Connect branch lines to top of main serving only fixtures located on floor above.

3.2 TESTS

A. General: Test system either in its entirety or in sections. Submit testing plan to COR 14 days prior to test date.
B. Potable Water System: Test after installation of piping and domestic water heaters, but before piping is concealed, before covering is applied, and before plumbing fixtures are connected. Fill systems with water and maintain hydrostatic pressure of 150 psi (1040 kPa) gage for two hours. No decrease in pressure is allowed. Provide a pressure gage with a shutoff and bleeder valve at the highest point of the piping being tested.
   1. Pneumatic testing shall not be permitted.
C. All Other Piping Tests: Test new installed piping under 1-1/2 times actual operating conditions and prove tight.

3.3 STERILIZATION

A. After tests have been successfully completed, thoroughly flush and sterilize the interior domestic water distribution system in accordance with AWWA C651.
   1. Replace startup strainers prior to sterilization.
B. Use liquid chlorine or hypochlorite for sterilization.
C. All sterilization must be coordinated with COR. The COR must approve the sterilization plan and Contractor shall demonstrate that the water distribution system is completely isolated from the building water system to ensure no cross contamination or backflow to the building water distribution system.

3.4 COMMISSIONING

A. Provide commissioning documentation accordance with the requirements of Section 22 08 00, COMMISSIONING FOR PLUMBING SYSTEMS.
B. Components provided under this section of the specification will be tested as part of a larger system.

3.5 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer' s technical representative for two hours to instruct VA Personnel in operation and maintenance of the system.
B. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

- - - END - - -

SECTION 22 11 23
DOMESTIC WATER PUMPS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Hot water circulating pumps.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.
B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.
D. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.
E. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.
F. Section 22 05 12, GENERAL MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT.
G. Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

1.3 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
B. American Society of Mechanical Engineers (ASME):
    1. ASME Boiler and Pressure Code
        a. BPVC Section VIII-1-2015 Rules for Construction of Pressure Vessels, Division 1
        b. BPVC Section VIII-2-2015 Rules for Construction of Pressure Vessels, Division 2-Alternative Rules
C. American Society for Testing and Materials (ASTM):
    1. A48/A48M-2003 (R2012) Standard Specification for Gray Iron Castings
    2. B584-2014 Standard Specification for Copper Alloy Sand Castings for General Applications
D. International Code Council (ICC)
    1. IPC-2021 International Plumbing Code
E. National Electrical Manufacturers Association (NEMA):
    1. ICS 6-1993 (R2001, R2006) Industrial Control and Systems: Enclosures

2. 250-2014 Enclosures for Electrical Equipment (1000 Volts Maximum)

F. NSF International (NSF)
1. 61-2014a Drinking Water System Components – Health Effects
2. 372-2011 Drinking Water System Components – Lead Content

G. Underwriters' Laboratories, Inc. (UL):
1. 508-1999 (R2013) Standards for Industrial Control Equipment
2. 778-2010 (R2014) Standard for Motor-Operated Water Pumps

1.4 SUBMITTALS

A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 22 11 23, DOMESTIC WATER PUMPS", with applicable paragraph identification.

C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.
1. Pump:
a. Manufacturer and model.
b. Operating speed.
c. Capacity.
d. Characteristic performance curves.
1) Motor:
(a) Manufacturer, frame, and type.
(1) Speed.
(2) Current Characteristics.
(3) Efficiency.
2. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replacement parts, and troubleshooting guide:
a. Include complete list indicating all components of the systems.
b. Include complete diagrams of the internal wiring for each item of equipment.

c. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

D. Completed System Readiness Checklist provided by the CxA and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

E. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

1.5 QUALITY ASSURANCE

A. General:

1. UL Compliance: Comply with UL 778 for motor-operated water pumps.
2. Design Criteria:
   a. Pump sizes, capacities, pressures, operating characteristics and efficiency shall be as scheduled.
   b. Head-capacity curves shall slope up to maximum head at shut-off. Select pumps near the midrange of the curve, and near the point of maximum efficiency, without approaching the pump curve end point and possible cavitation and unstable operation. Select pumps for open systems so that required net positive suction head (NPSHR) does not exceed the net positive head available (NPSHA).
   c. Pump Driver: Furnish with pump. Size shall be non-overloading at any point on the head-capacity curve, including in a parallel or series pumping installation with one pump in operation.
   d. Provide all pumps with motors, impellers, drive assemblies, bearings, coupling guard and other accessories specified. Statically and dynamically balance all rotating parts.
   e. Furnish each pump and motor with a nameplate giving the manufacturers name, serial number of pump, capacity in GPM and head in feet at design condition, horsepower, voltage, frequency, speed and full load current and motor efficiency.
   f. Test all pumps before shipment. The manufacturer shall certify all pump ratings.

g. After completion of balancing, provide replacement of impellers or trim impellers to provide specified flow at actual pumping head, as installed.

3. Hot Water Circulating and Recirculating Pumps: Components shall be assembled by a single manufacturer and the pump motor assembly shall be the standard cataloged product of the manufacturer.

1.6 AS-BUILT DOCUMENTATION

A. Refer to Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Material or equipment containing a weighted average of greater than 0.25 percent lead shall be prohibited in any potable water system intended for human consumption, and shall be certified in accordance with NSF 61 or NSF 372.

2.2 HOT WATER RECIRCULATING PUMPS

A. General:

1. Mounting shall be in-line, vertical, or horizontal.
2. Pump shall operate continuously with on-off switch, or with an HOA switch for automatically controlled pumps, for manual shut down. In the inlet and outlet piping of the pump, shutoff valves shall be installed to permit service to the pump, strainer, and check valve without draining the system.
3. A check valve shall be installed in the pump discharge piping immediately downstream of the pump. A strainer with drain valve and removable strainer screen or basket shall be installed immediately upstream of the pump.

B. Horizontal, Wet-Rotor Circulators:

1. The pumps shall be of the high efficiency type specifically designed for quiet operation.
2. Pump shall have sensorless control to automatically adjust pump performance as required.
3. Pump to be suitable for 203°F (110°C) operation at 150 psi (10 Bar) working pressure.

4. The pumps shall have a shaft-less, wet rotor design with a ceramic ball bearing lubricated by the system fluid.
5. Pump to have three standard operating modes; Proportional Pressure, Constant Pressure and Constant Speed and two auxiliary modes; the Automatic Air Purge and Standby.
6. Motor shall be spherical electronically commutated motor, permanent magnet (ECM/PM).
7. Motor shall be non-overloading at any point on the entire pump curve.
8. Motor shall be protected from contaminents to prevent clogging
9. Pumps shall be capable of speed modulation across the full speed range.

PART 3 - EXECUTION

3.1 STARTUP AND TESTING

A. Make tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.
B. System Test: After installation is completed provide an operational test of the completed system including flow rates, pressure compliance, alarms and all control functions.
C. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.
D. The CxA will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the COR and CxA. Contractor shall provide a minimum of 10 working days prior to startup and testing.

3.2 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.
B. Components provided under this section of the specification will be tested as part of a larger system.

3.3 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer' s technical representative for one hour to instruct VA Personnel in operation and maintenance of the system.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

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SECTION 22 13 00
FACILITY SANITARY AND VENT PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section pertains to sanitary sewer and vent systems, including piping, equipment and all necessary accessories as designated in this section.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.
B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
C. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.
D. Section 07 84 00, JOINT FIRESTOPPING.
E. Section 07 84 13, PENETRATION FIRESTOPPING.
F. Section 07 92 00, JOINT SEALANTS.
G. Section 09 91 24, INTERIOR PAINTING.
H. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.
I. Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.
J. Section 31 20 11, EARTHWORK.

1.3 SUBMITTALS

A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
B. Information and material submitted under this section shall be marked “SUBMITTED UNDER SECTION 22 13 00, FACILITY SANITARY AND VENT PIPING”, with applicable paragraph identification.
C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.
    1. Piping.
    2. Floor Drains.
    3. Cleanouts.
    4. Trap Seal Protection.

5. Penetration Sleeves.
6. Pipe Fittings.
7. Traps.
8. Exposed Piping and Fittings.

D. Detailed shop drawing of clamping device and extensions when required in connection with the waterproofing membrane or the floor drain.

E. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replaceable parts, and troubleshooting guide:
1. Include complete list indicating all components of the systems.
2. Include complete diagrams of the internal wiring for each item of equipment.
3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

F. Shop drawings for all double containment piping systems shall be submitted and shall include details of pipe fabrications (including supporting devices, method of attachment, spacing, etc.), prefabricated double containment fitting dimensions, starting and terminating connections, high-point vent and low-point drain details for the secondary containment, valves and accessories. Submit joint details, methods and location of supports and all other pertinent technical data for all piping to be furnished. Vent & drain locations shall be shown. Leak detection points and equipment shall be shown on shop drawings.

1.4 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Where conflicts occur these specifications and the VHA standard will govern.

B. American Society of Mechanical Engineers (ASME):
1. A13.1-2007 Identification of Piping Systems
2. A112.36.2M-1991 Cleanouts
3. A112.6.3-2019 Floor and Trench Drains
4. B1.20.1-2013 Pipe Threads, General Purpose (Inch)

5. B16.1-2015 Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
6. B16.4-2016 Grey Iron Threaded Fittings Classes 125 and 250
7. B16.15-2018 Cast Copper Alloy Threaded Fittings, Classes 125 and 250
8. B16.18-2018 Cast Copper Alloy Solder Joint Pressure Fittings
9. B16.21-2016 Nonmetallic Flat Gaskets for Pipe Flanges
10. B16.22-2018 Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings
11. B16.23-2016 Cast Copper Alloy Solder Joint Drainage Fittings: DWV
12. B16.24-2016 Cast Copper Alloy Pipe Flanges and Flanged Fittings, and Valves: Classes 150, 300, 600, 900, 1500, and 2500
13. B16.29-2017 Wrought Copper and Wrought Copper Alloy Solder-Joint Drainage Fittings: DWV
14. B16.39-2014 Malleable Iron Threaded Pipe Unions Classes 150, 250, and 300
15. B18.2.1-2012 Square, Hex, Heavy Hex, and Askew Head Bolts and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws (Inch Series)

C. American Society of Sanitary Engineers (ASSE):
1. 1001-2017 Performance Requirements for Atmospheric Type Vacuum Breakers
2. 1018-2001 Performance Requirements for Trap Seal Primer Valves - Potable Water Supplied
3. 1044-2015 Performance Requirements for Trap Seal Primer Devices - Drainage Types and Electronic Design Types
4. 1079-2012 Performance Requirements for Dielectric Pipe Unions

D. American Society for Testing and Materials (ASTM):
1. A53/A53M-2018 Standard Specification for Pipe, Steel, Black And Hot-Dipped, Zinc-coated, Welded and Seamless
2. A74-2017 Standard Specification for Cast Iron Soil Pipe and Fittings
3. A888-2018a Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications
4. B32-2014 Standard Specification for Solder Metal

5. B43-2015 Standard Specification for Seamless Red Brass Pipe, Standard Sizes
6. B88-2016 Standard Specification for Seamless Copper Water Tube
7. B306-2013 Standard Specification for Copper Drainage Tube (DWV)
8. B687-2016 Standard Specification for Brass, Copper, and Chromium-Plated Pipe Nipples
9. B813-2016 Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube
10. B828-2016 Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings
11. C564-2014 Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings
12. D2321-2018 Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
13. D2564-2018 Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
14. D2665-2014 Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings
15. D2855-2015 Standard Practice for Two-Step (Primer and Solvent Cement) Method of Joining Poly(Vinyl Chloride) (PVC) or Chlorinated Poly (Vinyl Chloride) CPVCP Pipe and Piping Components with Tapered Sockets
16. D5926-2015 Standard Specification for Poly(Vinyl Chloride) (PVC) Gaskets for Drain, Waste, and Vent (DWV), Sewer, Sanitary, and Storm Plumbing Systems
17. F402-2018 Standard Practice for Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings
18. F477-2014 Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
19. F1545-2015e1 Standard Specification for Plastic-Lined Ferrous Metal Pipe, Fittings, and Flanges

E. Cast Iron Soil Pipe Institute (CISPI):
   1. Cast Iron Soil Pipe and Fittings Handbook

2. 301-2012 Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications
3. 310-2012 Specification for Coupling for Use in Connection with Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications

F. Copper Development Association, Inc. (CDA):
1. A4015-14/19 Copper Tube Handbook

G. International Code Council (ICC):
1. IPC-2021 International Plumbing Code

H. Manufacturers Standardization Society (MSS):
1. SP-123-2018 Non-Ferrous Threaded and Solder-Joint Unions for Use with Copper Water Tube

I. National Fire Protection Association (NFPA):
1. 70-2021 National Electrical Code (NEC)

J. Underwriters' Laboratories, Inc. (UL):
1. 508-2013 Standard For Industrial Control Equipment

1.5 AS-BUILT DOCUMENTATION

A. Comply with requirements in Paragraph '' AS-BUILT DOCUMENTATION'' of Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

PART 2 - PRODUCTS

2.1 SANITARY WASTE, DRAIN, AND VENT PIPING

A. Cast iron waste, drain, and vent pipe and fittings
1. Cast iron waste, drain, and vent pipe and fittings shall be used for the following applications:
a. Pipe buried in or in contact with earth.
b. Sanitary pipe extensions to a distance of approximately 1500 mm (5 feet) outside of the building.
c. Interior waste and vent piping above grade.
2. Cast iron Pipe shall be bell and spigot or hubless (plain end or no-hub or hubless).
3. The material for pipe and fittings shall be cast iron soil pipe and fittings and shall conform to the requirements of CISPI Standard 301, ASTM A-888, or ASTM A-74.

4. Joints for hubless pipe and fittings shall conform to the manufacturer' s installation instructions. Couplings for hubless joints shall conform to CISPI 310. Joints for hub and spigot pipe shall be installed with compression gaskets conforming to the requirements of ASTM Standard C-564.

B. Polyvinyl Chloride (PVC)
   1. Polyvinyl chloride (PVC) pipe and fittings are permitted where the waste temperature is below 60°C (140°F).
   2. PVC piping and fittings shall NOT be used for the following applications:
      a. Waste collected from steam condensate drains spaces such as mechanical equipment rooms, kitchens, SPD, and sterilizer areas.
      b. Vertical waste and soil stacks. serving more than two floors
      c. Exposed in mechanical equipment rooms.
      d. Exposed inside of ceiling return plenums.
   3. Polyvinyl chloride sanitary waste, drain, and vent pipe and fittings shall be schedule 40 solid core sewer piping conforming to ASTM D 1785 and ASTM D2665, sewer and drain series with ends for solvent cemented joints.
   4. Fittings:
      a. PVC fittings shall be solvent welded socket type using solvent cement conforming to ASTM D2564.

C. Acrylonitrile Butadiene Styrene (ABS)
   1. Acrylonitrile butadiene styrene sewer pipe and fittings shall be utilized in the following applications and locations:
      a. Sanitary sewer piping, below grade/buried within building footprint.
      b. Sanitary sewer piping, extension of piping to distance approximately 1500 mm (5 feet) outside building walls.
      c. Vent piping, inside building.
   2. Acrylonitrile butadiene styrene sanitary sewer pipe and fittings shall be schedule 40 solid core sewer piping conforming to ASTM D2661, with ends for solvent cemented joints.

3. Acrylonitrile butadiene styrene joints shall be solvent welded socket type using solvent cement conforming to ASTM D2235.

2.2 SPECIALTY PIPE FITTINGS

A. Transition pipe couplings shall join piping with small differences in outside diameters or different materials. End connections shall be of the same size and compatible with the pipes being joined. The transition coupling shall be elastomeric, sleeve type reducing or transition pattern and include shear and corrosion resistant metal, tension band and tightening mechanism on each end. The transition coupling sleeve coupling shall be of the following material:
   1. For cast iron soil pipes, the sleeve material shall be rubber conforming to ASTM C564.
   2. For ABS soil pipes, the sleeve material shall be elastomeric seal or PVC, conforming to ASTM F 477 or ASTM D5926.
   3. For dissimilar pipes, the sleeve material shall be of a material compatible with the pipe materials being joined.

B. The dielectric fittings shall conform to ASSE 1079 with a pressure rating of 860 kPa (125 psig) at a minimum temperature of 82 C (180 F). The end connection shall be solder joint copper alloy and threaded ferrous.

C. Dielectric flange insulating kits shall be of non conducting materials for field assembly of companion flanges with a pressure rating of 1035 kPa (150 psig). The gasket shall be neoprene or phenolic. The bolt sleeves shall be phenolic or polyethylene. The washers shall be phenolic with steel backing washers.

D. The di-electric nipples shall be electroplated steel nipple complying with ASTM F 1545 with a pressure ratings of 2070 kPa (300 psig) at 107 C (225 F). The end connection shall be male threaded. The lining shall be inert and noncorrosive propylene.

2.3 CLEANOUTS

A. Cleanouts shall be the same size as the pipe, up to 100 mm (4 inches); and not less than 100 mm (4 inches) for larger pipe. Cleanouts shall be easily accessible and shall be gastight and watertight. Minimum clearance of 600 mm (24 inches) shall be provided for clearing a clogged sanitary line.

B. Floor cleanouts shall be gray iron housing with clamping device and round, secured, scoriated, gray iron cover conforming to ASME A112.36.2M. A gray iron ferrule with hubless, socket, inside calk or spigot connection and counter sunk, taper-thread, brass or bronze closure plug shall be included. The frame and cover material and finish shall be nickel-bronze copper alloy with a square shape. The cleanout shall be vertically adjustable for a minimum of 50 mm (2 inches). When a waterproof membrane is used in the floor system, clamping collars shall be provided on the cleanouts. Cleanouts shall consist of wye fittings and eighth bends with brass or bronze screw plugs.

1. Cleanouts in the resilient tile floors, quarry tile and ceramic tile floors shall be provided with square top covers recessed for tile insertion.
2. In the carpeted areas, carpet cleanout markers shall be provided.
3. Two way cleanouts shall be provided where indicated on drawings and at every building exit.
4. The loading classification for cleanouts in sidewalk areas or subject to vehicular traffic shall be heavy duty type.

C. Cleanouts shall be provided at or near the base of the vertical stacks with the cleanout plug located approximately 600 mm (24 inches) above the floor. If there are no fixtures installed on the lowest floor, the cleanout shall be installed at the base of the stack. The cleanouts shall be extended to the wall access cover. Cleanout shall consist of sanitary tees. Nickel-bronze square frame and stainless steel cover with minimum opening of 150 by 150 mm (6 by 6 inches) shall be furnished at each wall cleanout. Where the piping is concealed, a fixture trap or a fixture with integral trap, readily removable without disturbing concealed pipe, shall be accepted as a cleanout equivalent providing the opening to be used as a cleanout opening is the size required.

D. In horizontal runs above grade, cleanouts shall consist of cast brass tapered screw plug in fitting or caulked/hubless cast iron ferrule. Plain end (hubless) piping in interstitial space or above ceiling may use plain end (hubless) blind plug and clamp.

2.4 FLOOR DRAINS

A. Type C (FD-C) floor drain shall comply with ANSI A112.6.3. The type C floor drain shall have a cast iron body, double drainage pattern, clamping device, light duty square or round nickel bronze adjustable strainer and grate with vandal proof screws. The grate shall be square, 150 mm (6 inches) minimum.

B. Type W (FD-W) Open sight drains (OSD's) shall be cast iron, constructed as shown by detail.

C. Type Z (FD-Z) trench drain shall consist of molded polymer or composite body, with 304 Stainless Steel grating.

2.5 TRAPS

A. Traps shall be provided on all sanitary branch waste connections from fixtures or equipment not provided with traps. Exposed brass shall be polished brass chromium plated with nipple and set screw escutcheons. Concealed traps may be rough cast brass or same material as pipe connected to. Slip joints are not permitted on sewer side of trap. Traps shall correspond to fittings on cast iron soil pipe or steel pipe respectively, and size shall be as required by connected service or fixture.

2.6 TRAP SEAL PRIMER VALVES AND TRAP SEAL PRIMER SYSTEMS

A. Trap Primer: The trap seal primer valve shall be hydraulic, supply type with a pressure rating of 5.98 kPa (125 psig) and conforming to standard ASSE 1018.
   1. The inlet and outlet connections shall be 15 mm or DN15 (NPS ½ inch)
   2. The trap seal primer valve shall be fully automatic with an all brass or bronze body.
   3. The trap seal primer valve shall be activated by a drop in building water pressure, no adjustment required.
   4. The trap seal primer valve shall include a manifold when serving two, three, or four traps.
   5. The manifold shall be omitted when serving only one trap.

2.7 WATERPROOFING

A. A sleeve flashing device shall be provided at points where pipes pass through membrane waterproofed floors or walls. The sleeve flashing device shall be manufactured, cast iron fitting with clamping device that forms a sleeve for the pipe floor penetration of the floor membrane. A galvanized steel pipe extension shall be included in the top of the fitting that will extend 50 mm (2 inches) above finished floor and galvanized steel pipe extension in the bottom of the fitting that will extend through the floor slab. A waterproof caulked joint shall be provided at the top hub.

PART 3 - EXECUTION

3.1 PIPE INSTALLATION

A. The pipe installation shall comply with the requirements of the International Plumbing Code (IPC) and these specifications.

B. Branch piping shall be installed for waste from the respective piping systems and connect to all fixtures, valves, cocks, outlets, casework, cabinets and equipment, including those furnished by the Government or specified in other sections.

C. Pipe shall be round and straight. Cutting shall be done with proper tools. Pipe shall be reamed to full size after cutting.

D. All pipe runs shall be laid out to avoid interference with other work.

E. The piping shall be installed above accessible ceilings where possible.

F. The piping shall be installed to permit valve servicing or operation.

G. The piping shall be installed free of sags and bends.

H. Seismic restraint shall be installed where required by code.

I. Changes in direction for soil and waste drainage and vent piping shall be made using appropriate branches, bends and long sweep bends. Sanitary tees and short sweep quarter bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Long turn double wye branch and eighth bend fittings shall be used if two fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Proper size of standard increaser and reducers shall be used if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

J. Buried soil and waste drainage and vent piping shall be laid beginning at the low point of each system. Piping shall be installed true to grades and alignment indicated with unbroken continuity of invert. Hub ends shall be placed upstream. Required gaskets shall be installed according to manufacturer' s written instruction for use of lubricants, cements, and other installation requirements.

K. Cast iron piping shall be installed according to CISPI' s '' Cast Iron Soil Pipe and Fittings Handbook,'' Chapter IV, '' Installation of Cast Iron Soil Pipe and Fittings'' .

L. Aboveground PVC piping shall be installed according to ASTM D2665. Underground PVC piping shall be installed according to ASTM D2321.

M. Abovegrade ABS piping shall be installed according to ASTM D2261. Underground ABS piping shall be installed according to ASTM D2321 and F1668.

3.2 JOINT CONSTRUCTION

A. Hubless or No-hub, cast iron piping shall be joined in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless piping coupling joints.

B. For threaded joints, thread pipe with tapered pipe threads according to ASME B1.20.1. The threads shall be cut full and clean using sharp disc cutters. Threaded pipe ends shall be reamed to remove burrs and restored to full pipe inside diameter. Pipe fittings and valves shall be joined as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is required by the pipe service
2. Pipe sections with damaged threads shall be replaced with new sections of pipe.

C. For PVC piping, solvent cement joints shall be used for joints. All surfaces shall be cleaned and dry prior to applying the primer and solvent cement. Installation practices shall comply with ASTM F402. The joint shall conform to ASTM D2855 and ASTM D2665 appendixes.

D. For ABS piping, solvent cement joints shall be used for joints. All surfaces shall be cleaned and dry prior to applying the primer and solvent cement. Installation practices shall comply with ASTM F1668 and ASTM D2321. The joint shall conform to ASTM D2235 and ASTM D2661 appendixes.

3.3 SPECIALTY PIPE FITTINGS

A. Transition coupling shall be installed at pipe joints with small differences in pipe outside diameters.

B. Dielectric fittings shall be installed at connections of dissimilar metal piping and tubing.
C. Specialty fittings compatible with the connected materials shall be utilized to join piping of different types.

3.4 PIPE HANGERS, SUPPORTS AND ACCESSORIES:

A. All piping shall be supported according to the International Plumbing Code (IPC), Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING, and these specifications. Where conflicts arise between these the code and Section 22 05 11, the most restrictive or the requirement that specifies supports with highest loading or shortest spacing shall apply.
B. Hangers, supports, rods, inserts and accessories used for pipe supports shall be shop coated with zinc chromate primer paint. Electroplated copper hanger rods, hangers and accessories may be used with copper tubing.
C. Horizontal piping and tubing shall be supported within 300 mm (12 inches) of each fitting or coupling.
D. Horizontal cast iron piping shall be supported with the following maximum horizontal spacing and minimum hanger rod diameters:
    1. 40 mm or DN40 to 50 mm or DN50 (NPS 1-1/2 inch to NPS 2 inch): 1500 mm (60 inches) with 10 mm (3/8 inch) rod.
    2. 80 mm or DN 80 (NPS 3 inch): 1500 mm (60 inches) with 13 mm (\'bd inch) rod.
    3. 100 mm or DN100 to 125 mm or DN125 (NPS 4 to NPS 5): 1500 mm (60 inches) with 16 mm (5/8 inch) rod.
    4. 150 mm or DN150 to 200 mm or DN200 (NPS 6 inch to NPS 8 inch): 1500 mm (60 inches) with 19 mm (\'be inch) rod.
E. The maximum spacing for plastic pipe shall be 1.22 m (4 feet).
F. Vertical piping and tubing shall be supported at the base, at each floor, and at intervals no greater than 4.57 m (15 feet).
G. In addition to the requirements in Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING, floor, Wall and Ceiling Plates, Supports, Hangers shall have the following characteristics:
    1. Solid or split unplated cast iron.
    2. All plates shall be provided with set screws.

3. Height adjustable clevis type pipe hangers.
4. Adjustable floor rests and base flanges shall be steel.
5. Hanger rods shall be low carbon steel, fully threaded or threaded at each end with two removable nuts at each end for positioning rod and hanger and locking each in place.
6. Riser clamps shall be malleable iron or steel.
7. Rollers shall be cast iron.
8. See Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING, for requirements on insulated pipe protective shields at hanger supports.

H. Miscellaneous materials shall be provided as specified, required, directed or as noted on the drawings for proper installation of hangers, supports and accessories. If the vertical distance exceeds 6 m (20 feet) for cast iron pipe additional support shall be provided in the center of that span. All necessary auxiliary steel shall be provided to provide that support.

I. Cast escutcheon with set screw shall be provided at each wall, floor and ceiling penetration in exposed finished locations and within cabinets and millwork.

J. Penetrations:
1. Fire Stopping: Where pipes pass through fire partitions, fire walls, smoke partitions, or floors, a fire stop shall be installed that provides an effective barrier against the spread of fire, smoke, and gases as specified in Section 07 84 00, FIRESTOPPING. Clearances between raceways and openings shall be completely filled and sealed with the fire stopping materials.
2. Water proofing: At floor penetrations, clearances shall be completely sealed around the pipe and make watertight with sealant as specified in Section 07 92 00, JOINT SEALANTS.

K. Piping shall conform to the following:
1. Waste and Vent Drain to main stacks:
a. 80 mm or DN 80 (3 inches) and smaller: 2% minimum slope
b. 100 mm or DN 100 (4 inches) and larger : 1% minimum slope

3.5 TESTS

A. Sanitary waste and drain systems shall be tested either in its entirety or in sections.

B. Submit testing plan to COR 14 days prior to test date.

C. Waste System tests shall be conducted before fixtures are connected. Water and air tests shall be conducted.

1. If entire system is tested for a water test, tightly close all openings in pipes except highest opening, and fill system with water to point of overflow. If the waste system is tested in sections, tightly plug each opening except highest opening of section under test, fill each section with water and test with at least a 3 m (10 foot) head of water. In testing successive sections, test at least upper 3 m (10 feet) of next preceding section so that each joint or pipe except upper most 3 m (10 feet) of system has been submitted to a test of at least a 3 m (10 foot) head of water. Water shall be kept in the system, or in portion under test, for at least 15 minutes before inspection starts. System shall then be tight at all joints.
2. For an air test, an air pressure of 34 kPa (5 psig) gauge shall be maintained for at least 15 minutes without leakage. A force pump and mercury column gauge shall be used for the air test.
3. After installing all fixtures and equipment, open water supply so that all p-traps can be observed. For 15 minutes of operation, all p-traps shall be inspected for leaks and any leaks found shall be corrected.
4. Final Tests: Either one of the following tests may be used.
   a. Smoke Test: After fixtures are permanently connected and traps are filled with water, fill entire drainage and vent systems with smoke under pressure of .25 kPa (1 inch of water) with a smoke machine. Chemical smoke is prohibited.
   b. Peppermint Test: Introduce 60 ml (2 ounces) of peppermint into each line or stack.

3.6 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

B. Components provided under this section of the specification will be tested as part of a larger system.

3.7 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer' s technical representative for two hours to instruct VA Personnel in operation and maintenance of the system.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

- - - END - - -

SECTION 22 14 00
FACILITY STORM DRAINAGE

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section describes the requirements for storm drainage systems, including piping and all necessary accessories as designated in this section.

B. A complete listing of all acronyms and abbreviations are included in Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

D. Section 07 84 00, JOINT FIRESTOPPING.

E. Section 07 84 13, PENETRATION FIRESTOPPING.

F. Section 07 92 00, JOINT SEALANTS.

G. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

H. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

I. Section 22 05 33, HEAT TRACING FOR PLUMBING PIPING.

J. Section 22 07 11, PLUMBING INSULATION.

K. SECTION 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

L. Section 31 20 11, EARTHWORK.

1.3 APPLICABLE PUBLICATIONS

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

B. American Society of Mechanical Engineers (ASME):

1. A112.6.4-2003 (R2012) Roof, Deck, and Balcony Drains
2. A13.1-2007 (R2013) Scheme for Identification of Piping Systems
3. B1.20.1-2013 Pipe Threads, General Purpose, Inch
4. B16.3-2011 Malleable Iron Threaded Fittings: Classes 150 and 300
5. B16.9-2012 Factory-Made Wrought Buttwelding Fittings
6. B16.11-2011 Forged Fittings, Socket-Welding and Threaded

7. B16.12-2009 (R2014) Cast Iron Threaded Drainage Fittings
8. B16.15-2013 Cast Copper Alloy Threaded Fittings: Classes 125 and 250
9. B16.18-2012 Cast Copper Alloy Solder-Joint Pressure Fittings
10. B16.22-2013 Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings
11. B16.23-2011 Cast Copper Alloy Solder Joint Drainage Fittings - DWV
12. B16.29-2012 Wrought Copper and Wrought Copper Alloy Solder-Joint Drainage Fittings – DWV

C. American Society of Sanitary Engineering (ASSE)
1. 1079-2012 Performance Requirements for Dielectric Pipe Unions

D. American Society for Testing and Materials (ASTM):
1. A47/A47M-1999 (R2014) Standard Specification for Ferritic Malleable Iron Castings
2. A53/A53M-2012 Standard Specification for Pipe, Steel, Black And Hot-Dipped, Zinc-coated Welded and Seamless
3. A74-2013a Standard Specification for Cast Iron Soil Pipe and Fittings
4. A183-2014 Standard Specification for Carbon Steel Track Bolts and Nuts
5. A312/A312M-2015 Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
6. A536-1984(R2014) Standard Specification for Ductile Iron Castings
7. A733-2013 Standard Specification for Welded and Seamless Carbon Steel and Austenitic Stainless Steel Pipe Nipples
8. A888-2013a Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications
9. B32-2008 (R2014) Standard Specification for Solder Metal
10. B61-2008 (R2013) Standard Specification for Steam or Valve Bronze Castings
11. B62-2009 Standard Specification for Composition Bronze or Ounce Metal Castings
12. B75/B75M-2011 Standard Specification for Seamless Copper Tube
13. B88-2014 Standard Specification for Seamless Copper Water Tube

14. B306-2013 Standard Specification for Copper Drainage Tube (DWV)
15. B584-2014 Standard Specification for Copper Alloy Sand Castings for General Applications
16. B687-1999 (R2011) Standard Specification for Brass, Copper, and Chromium-Plated Pipe Nipples
17. B828-2002 (R2010) Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings
18. B813-2010 Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube
19. C564-2014 Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings
20. C1173-2010 (R2014) Standard Specification for Flexible Transition Couplings for Underground Piping Systems
21. D1785-2012 Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80 and 120
22. D2000-2012 Standard Classification System for Rubber Products in Automotive Applications
23. D2321-2014e1 Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
24. D2564-2012 Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems
25. D2665-2014 Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings
26. D2855-1996 (R2010) Standard Practice for Making Solvent-Cemented Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings
27. D4101-2014 Standard Specification for Polypropylene Injection and Extrusion Materials
28. D5926-2011 Standard for Poly (Vinyl Chloride) (PVC) Gaskets for Drain, Waste, and Vent (DWV), Sewer, Sanitary, and Storm Plumbing Systems
29. F477-2014 Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
30. F656-2010 Standard Specification for Primers for Use in Solvent Cement Joints of Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings

31. F1545-2015 Standard Specification for Plastic-Lined Ferrous Metal Pipe, Fittings, and Flanges

E. American Welding Society (AWS):
1. A5.8M/A5.8 AMD1-2011 Specification for Filler Metals for Brazing and Braze Welding

F. Cast Iron Soil Pipe Institute (CISPI):
1. 301-2012 Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications
2. 310-2012 Standard Specification for Coupling for Use in Connection with Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications

G. International Code Council (ICC):
1. IPC-2018 International Plumbing Code

H. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS):
1. SP-72-2010a Ball Valves with Flanged or Butt-Welding Ends for General Service
2. SP-110-2010 Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends

1.4 SUBMITTALS

A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Information and material submitted under this section shall be marked “SUBMITTED UNDER SECTION 22 14 00, FACILITY STORM DRAINAGE”, with applicable paragraph identification.

C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.
1. Pipe and Fittings.
2. Specialty Pipe Fittings.
3. Cleanouts.
4. Roof Drains.

5. Expansion Joints.
6. Sleeve Flashing Devices.
7. Detailed shop drawing of clamping device and extensions when required in connection with the waterproofing membrane.

D. Completed System Readiness Checklist provided by the CxA and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

E. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

1.5 QUALITY ASSURANCE

A. Bio-Based Materials: For products designated by the USDA’s Bio-Preferred Program, provide products that meet or exceed USDA recommendations for bio-based content, so long as products meet all performance requirements in this specifications section. For more information regarding the product categories covered by the Bio-Preferred Program, visit http://www.biopreferred.gov.

1.6 AS-BUILT DOCUMENTATION

A. Comply with requirements in Paragraph '' AS-BUILT DOCUMENTATION'' of Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

PART 2 - PRODUCTS

2.1 STORM WATER DRAIN PIPING

A. Cast Iron Storm Pipe and Fittings:
   1. Cast iron storm pipe and fittings shall be used for the following applications:
      a. Interior storm piping above grade.
      b. The cast iron storm pipe shall be bell and spigot, or hubless (plain end or no-hub) as required by selected jointing method.
      c. The material for all pipe and fittings shall be cast iron soil pipe and fittings and shall conform to the requirements of CISPI 301, ASTM A888, or ASTM A74.

d. Joints for hubless pipe and fittings shall conform to the manufacturer's installation instructions. Couplings for hubless joints shall conform to CISPI 310. Joints for hub and spigot pipe shall be installed with compression gaskets conforming to the requirements of ASTM C564.

2. Polyvinyl Chloride (PVC):
   a. PVC storm sewer pipe and fittings are permitted for single story structures except for mechanical equipment rooms and other areas containing air handling equipment or hot water generation equipment.
   b. PVC storm sewer pipe and fittings shall be schedule 40 solid core piping conforming to ASTM D1785 and ASTM D2665, Sewer and Drain Series, with ends for solvent cemented joints.
   c. PVC joints shall be solvent welded socket type using solvent cement conforming to ASTM D2564 and adhesive primer conforming to ASTM F656. Bio-based materials shall be utilized when possible.
3. Roof drain piping and body of drain in locations where the outdoor conditions are subject to freezing shall be insulated.

2.2 SPECIALTY PIPE FITTINGS

A. Transition pipe couplings shall join piping with small differences in outside diameters or be of different materials. End connections shall be of the same size and compatible with the pipes being joined. The transition coupling shall be unshielded, elastomeric, sleeve type reducing or transition pattern conforming with ASTM C1173 and include shear ring and corrosion resistant metal tension band and tightening mechanism on each end. The transition coupling sleeve coupling shall be of the following material:
   1. For cast iron soil pipes, the sleeve material shall be rubber conforming to ASTM C564.
   2. For PVC soil pipes, the sleeve material shall be elastomeric seal conforming to ASTM F477 or PVC conforming to ASTM D5926.
   3. For dissimilar pipes, the sleeve material shall be PVC conforming to ASTM D5926, or other material compatible with the pipe materials being joined.

4. Dielectric fittings shall conform to ASSE 1079 with a pressure rating of 1035 kPa (150 psig) at a minimum temperature of 82 degrees C (180 degrees F). The end connection shall be solder joint copper alloy and threaded ferrous.
5. Dielectric flanges shall conform to ASSE 1079 with a pressure rating of 1035 kPa (150 psig). The flange shall be a factory fabricated, bolted, companion flange assembly. The end connection shall be threaded or solder-joint copper alloy and threaded ferrous.
6. Dielectric flange insulating kits shall be of non-conducting materials for field assembly of companion flanges with a pressure rating of 1035 kPa (150 psig). The gasket shall be neoprene or phenolic. The bolt sleeves shall be phenolic or polyethylene. The washers shall be phenolic with steel backing washers.
7. Dielectric nipples shall be electroplated steel and shall conform with ASTM F1545 with a pressure ratings of 2070 kPa (300 psig) at 107 degrees C (225 degrees F). The end connection shall be male threaded. The lining shall be inert and noncorrosive propylene. Bio-based materials shall be utilized when possible.

2.3 CLEANOUTS

A. Cleanouts shall be the same size as the pipe, up to 100 mm (4 inches); not less than 100 mm (4 inches) for larger pipe. Cleanouts shall be easily accessible and shall be gastight and watertight. A minimum clearance of 600 mm (24 inches) shall be provided for clearing a clogged storm sewer line.

B. Floor cleanouts shall be gray iron housing with clamping device and round, secured, scoriated, gray iron cover conforming to ASME A112.36.2M. A gray iron ferrule with hubless, socket, inside caulk or spigot connection and counter sunk, taper-thread, brass or bronze closure plug shall be included. The frame and cover material and finish shall be nickel-bronze copper alloy with a square shape. The cleanout shall be vertically adjustable for a minimum of 50 mm (2 inches). When a waterproof membrane is used in the floor system, clamping collars shall be provided on the cleanouts. Cleanouts shall consist of wye fittings and eighth bends with brass or bronze screw plugs. Cleanouts in the resilient tile floors, quarry tile and ceramic tile floors shall be provided with square top covers recessed for tile insertion. In the carpeted areas, carpet cleanout markers shall be provided. Two way cleanouts shall be provided where indicated on the drawings and at each building exit. The loading classification for cleanouts in sidewalk areas or subject to vehicular traffic shall be heavy duty.

C. Cleanouts shall be provided at or near the base of the vertical stacks with the cleanout plug located approximately 600 mm (24 inches) above the floor. The cleanouts shall be extended to the wall access cover. Cleanout shall consist of sanitary tees. Nickel bronze square frame and stainless steel cover with minimum opening of 150 mm by 150 mm (6 inch by 6 inch) shall be provided at each wall cleanout.

D. In horizontal runs above grade, cleanouts shall consist of cast brass tapered screw plug in fitting or caulked/no hub cast iron ferrule. Plain end (no-hub) piping in interstitial space or above ceiling may use plain end (no-hub) blind plug and clamp.

2.4 ROOF DRAINS AND CONNECTIONS

A. Roof Drains: Roof Drains shall be cast iron with clamping device for making watertight connection and shall conform with ASME A112.6.4. Free openings through strainer shall be twice area of drain outlet. For roof drains not installed in connection with a waterproof membrane, a soft copper membrane shall be provided 300 mm (12 inches) in diameter greater than outside diameter of drain collar. An integral gravel stop shall be provided for drains installed on roofs having built up roofing covered with gravel or slag. Integral no-hub, soil pipe gasket or threaded outlet connection shall be provided.

1. Flat Roofs: The roof drain shall have a beehive or dome shaped strainer with integral flange not less than 300 mm (12 inches) in diameter. For an insulated roof, a roof drain with an adjustable drainage collar shall be provided, which can be raised or lowered to meet required insulation heights, sump receiver and deck clamp. The bottom section shall serve as roof drain during construction before insulation is installed.
2. Protective Roof Membrane Insulation Assembly: The roof drain shall have a perforated stainless steel extension filter, non-puncturing clamp ring, large sump with extra wide roof flange and deck clamp.
   a. Non pedestrian Roofs: The roof drain shall have large polypropylene or aluminum locking dome.
   b. Pedestrian Roof: The roof drain shall have a bronze promenade top 356 mm (14 inches) square, set in square secured frame support collar.
   c. Roof Drains, Overflow or Secondary (Emergency): Roof Drains identified as overflow or secondary (emergency) drains shall have a 50 mm (2 inch) water dam integral to the drain body.
   d. Roof drains in areas subject to freezing shall have heat tape and shall be insulated.

B. Expansion Joints: Expansions joints shall be heavy cast iron with cast brass or PVC expansion sleeve having smooth bearing surface working freely against a packing ring held in place and under pressure of a bolted gland ring, forming a water and air tight flexible joint. Asbestos packing is prohibited.

C. Downspout Nozzle: The downspout nozzle fitting shall be of brass, unfinished, with internal pipe thread for connection to downspout.

2.5 WATERPROOFING

A. A sleeve flashing device shall be provided at points where pipes pass through membrane waterproofed floors or walls. The sleeve flashing device shall be manufactured, cast iron fitting with clamping device that forms a sleeve for the pipe floor penetration of the floor membrane. A galvanized steel pipe extension shall be included in the top of the fitting that will extend 50 mm (2 inches) above finished floor and galvanized steel pipe extension in the bottom of the fitting that will extend through the floor slab. A waterproofed caulked joint shall be provided at the top hub.

PART 3 - EXECUTION

3.1 PIPE INSTALLATION

A. The pipe installation shall comply with the requirements of the IPC and these specifications.

B. Branch piping shall be installed from the piping system and connect to all drains and outlets.

C. Pipe shall be round and straight. Cutting shall be done with proper tools. Pipe, except for glass, shall be reamed to remove burrs and a clean smooth finish restored to full pipe inside diameter.

D. All pipe runs shall be laid out to avoid interference with other work/trades.

E. The piping shall be installed above accessible ceilings to allow for ceiling panel removal.

F. Unless otherwise stated on the documents, minimum horizontal slope shall be one inch for every 2.44 m (8 feet) (1 percent slope) of pipe length.

G. The piping shall be installed free of sags and bends.

H. Seismic restraint shall be installed where required by code.

I. Changes in direction for storm drainage piping shall be made using appropriate branches, bends and long sweep bends. Sanitary tees and short sweep ¼ bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Long turn double wye branch and 1/8 bend fittings shall be used if two drains are installed back to back or side by side with common drain pipe. Do not change direction of flow more than 90 degrees. Proper size of standard increaser and reducers shall be used if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

J. Buried storm drainage piping shall be laid beginning at the low point of each system. Piping shall be installed true to grades and alignment indicated with unbroken continuity of invert. Hub ends shall be placed upstream. Required gaskets shall be installed according to manufacturer's written instruction for use of lubricants, cements, and other installation requirements. Bio-based materials shall be utilized when possible.

K. Cast iron piping shall be installed according to CISPI' s '' Cast Iron Soil Pipe and Fittings Handbook,'' Chapter IV, '' Installation of Cast Iron Soil Pipe and Fittings'' .

L. Aboveground copper tubing shall be installed according to CDA A4015.

M. Aboveground PVC piping shall be installed according to ASTM D2665. Underground PVC piping shall be installed according to ASTM D2321.

3.2 JOINT CONSTRUCTION

A. Hubless, cast iron piping shall be joined in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless piping coupling joints.

B. For threaded joints, thread pipe with tapered pipe threads according to ASME B1.20.1. The threads shall be cut full and clean using sharp disc cutters. Threaded pipe ends shall be reamed to remove burrs and restored to full pipe inside diameter. Pipe fittings and valves shall be joined as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is required by the pipe service

2. Pipe sections with damaged threads shall be replaced with new undamaged sections of pipe at no additional time or cost to Government.

3.3 SPECIALTY PIPE FITTINGS

A. Transition coupling shall be installed at pipe joints with small differences in pipe outside diameters.

B. Dielectric fittings shall be installed at connections of dissimilar metal piping and tubing.

3.4 PIPE HANGERS, SUPPORTS AND ACCESSORIES

A. All piping shall be supported according to the IPC, Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING, and these specifications.

B. Hangers, supports, rods, inserts and accessories used for Pipe supports shall be shop coated with zinc Chromate primer paint. Electroplated copper hanger rods, hangers and accessories may be used with copper tubing.

C. Horizontal piping and tubing shall be supported within 300 mm (12 inches) of each fitting or coupling.

D. Horizontal cast iron piping shall be supported with the following maximum horizontal spacing and minimum hanger rod diameters:

1. NPS 1-1/2 to NPS 2 (DN 40 to DN 50): 1500 mm (60 inches) with 10 mm (3/8 inch) rod.
2. NPS 3 (DN 80): 1500 mm (60 inches) with 15 mm (1/2 inch) rod.
3. NPS 4 to NPS 5 (DN 100 to DN 125): 1500 mm (60 inches) with 18 mm (5/8 inch) rod.
4. NPS 6 to NPS 8 (DN 150 to DN 200): 1500 mm (60 inches) with 20 mm (3/4 inch) rod.
5. NPS 10 to NPS 12 (DN 250 to DN 300): 1500 mm (60 inches) with 23 mm (7/8 inch) rod.
6. The maximum support spacing for horizontal plastic shall be 1.22 m (4 feet).

E. Vertical piping and tubing shall be supported at the base, at each floor, and at intervals no greater than 4.6 m (15 feet).

F. In addition to the requirements in Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING, floor, wall and ceiling plates shall have the following characteristics:
   1. Solid or split unplated cast iron.
   2. All plates shall be provided with set screws.
   3. Height adjustable clevis type pipe hangers.
   4. Adjustable Floor Rests and Base Flanges shall be steel.
   5. Hanger Rods shall be low carbon steel, fully threaded or threaded at each end with two removable nuts at each end for positioning rod and hanger and locking each in place.
   6. Riser Clamps shall be malleable iron or steel.
   7. Roller shall be cast iron.
   8. Hangers and supports utilized with insulated pipe and tubing shall have 180 degree (minimum) metal protection shield centered on and welded to the hanger and support. The shield shall be 100 mm (4 inches) in length and be 1.6 mm (16 gage) steel. The shield shall be sized for the insulation.

G. Miscellaneous materials shall be provided as specified, required, directed or as noted on the drawings for proper installation of hangers, supports and accessories. If the vertical distance exceeds 6.1 m (20 feet) for cast iron pipe additional support shall be provided in the center of that span. All necessary auxiliary steel shall be provided to provide that support.

H. Cast escutcheon with set screw shall be installed at each wall, floor and ceiling penetration in exposed finished locations and within cabinets and millwork.

I. Penetrations:
   1. Fire Stopping: Where pipes pass through fire partitions, fire walls, smoke partitions, or floors, a fire stop shall be installed that provides an effective barrier against the spread of fire, smoke and gases as specified in Section 07 84 00, FIRESTOPPING. Clearances between raceways and openings shall be completely filled and sealed with the fire stopping materials.

2. Water proofing: At floor penetrations, Clearances around the pipe shall be completely sealed and made watertight with sealant as specified in Section 07 92 00, JOINT SEALANTS. Bio-based materials shall be utilized when possible.

3.5 INSULATION

A. Insulate all storm drain piping within building enclosure. Install insulation in accordance with the requirements of Section 22 07 11, PLUMBING INSULATION.

3.6 TESTS

A. Storm sewer system shall be tested either in its entirety or in sections.

B. Storm Water Drain tests shall be conducted before trenches are backfilled or fixtures are connected. A water test or air test shall be conducted, as directed.

1. If entire system is tested with water, tightly close all openings in pipes except the highest opening, and fill system with water to point of overflow. If system is tested in sections, tightly plug each opening except highest opening of section under test, fill each section with water and test with at least a 3 m (10 foot) head of water. In testing successive sections, test at least upper 3 m (10 feet) of next preceding section so that each joint or pipe except upper most 3 m (10 feet) of system has been submitted to a test of at least a 3 m (10 foot) head of water. Water shall be kept in the system, or in portion under test, for at least 15 minutes before inspection starts. System shall then be tight at all joints.
2. For an air test, an air pressure of 34 kPa (5 psig) gage shall be maintained for at least 15 minutes without leakage. A force pump and mercury column gage shall be used for the test.
3. Final Tests: While either one of the following tests may be used, Contractor shall check with VA as to which test will be performed.

a. Smoke Test: After fixtures are permanently connected and traps are filled with water, fill entire drainage and vent systems with smoke under pressure of 0.25 kPa (1 inch of water) with a smoke machine. Chemical smoke is prohibited.
b. Peppermint Test: Introduce .06 liters (2 ounces) of peppermint into each line or stack.

4. COR shall witness all tests. Contractor shall coordinate schedules with the COR and CxA. Contractor shall provide a minimum of 10 working days prior to flushing, disinfection/sterilization, startup, and testing.

3.7 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.
B. Components provided under this section of the specification will be tested as part of a larger system.

3.8 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer' s technical representative for one hour to instruct VA Personnel in operation and maintenance of the system.
B. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

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SECTION 22 40 00
PLUMBING FIXTURES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Plumbing fixtures, associated trim and fittings necessary to make a complete installation from wall or floor connections to rough piping, and certain accessories.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.
B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.
D. Section 07 92 00, JOINT SEALANTS.
E. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.
F. Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.
G. Section 22 11 00, FACILITY WATER DISTRIBUTION.
H. Section 22 13 00, FACILITY SANITARY AND VENT PIPING.

1.3 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
B. The American Society of Mechanical Engineers (ASME):
   1. A112.6.1M-1997 (R2012) Supports for Off-the-Floor Plumbing Fixtures for Public Use
   2. A112.19.1-2013 Enameled Cast Iron and Enameled Steel Plumbing Fixtures
   3. A112.19.2-2013 Ceramic Plumbing Fixtures
   4. A112.19.3-2008 Stainless Steel Plumbing Fixtures
C. American Society for Testing and Materials (ASTM):
   1. A276-2013a Standard Specification for Stainless Steel Bars and Shapes
   2. B584-2008 Standard Specification for Copper Alloy Sand Castings for General Applications
D. National Association of Architectural Metal Manufacturers (NAAMM):
   1. AMP 500-505 Metal Finishes Manual (1988)

E. American Society of Sanitary Engineers (ASSE):
   1. 1016-05 Performance Requirements for Individual Thermostatic, Pressure Balancing and Combination Pressure Balancing and Thermostatic Control Valves for Individual Fixture Fittings
F. CSA Group:
   1. B45.4-2008 (R2013) Stainless Steel Plumbing Fixtures
G. National Association of Architectural Metal Manufacturers (NAAMM):
   1. AMP 500-505 (R2013) Metal Finishes Manual
H. NSF International (NSF):
   1. 61 (2013) Drinking Water System Components – Health Effects
   2. 372 (2011) Drinking Water System Components – Lead Content
I. United States Department of Justice:
   1. American with Disabilities Act (A.D.A)
J. Environmental Protection Agency:
   1. EPA PL 93-523 1974; A 1999) Safe Drinking Water Act.
K. International Code Council:
   1. Building Code, ICC IBC 2021.
   2. Plumbing Code, ICC IPC 2021.

1.4 SUBMITTALS

A. Submittals, including number of required copies, will be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
B. Information and material submitted under this section will be marked "SUBMITTED UNDER SECTION 22 40 00, PLUMBING FIXTURES", with applicable paragraph identification.
C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, connections, and capacity.
D. Operating Instructions: Comply with requirements in Section 01 00 00, GENERAL REQUIREMENTS.
E. Completed System Readiness Checklist provided by the CxA and completed by the Contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

F. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

1.5 QUALITY ASSURANCE

A. Bio-Based Materials: For products designated by the USDA's Bio-Preferred Program, provide products that meet or exceed USDA recommendations for bio-based content, so long as products meet all performance requirements in this specifications section. For more information regarding the product categories covered by the Bio-Preferred Program, visit http://www.biopreferred.gov.

1.6 AS-BUILT DOCUMENTATION

A. Refer to Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

PART 2 - PRODUCTS

2.1 MATERIALS

A. 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 or NSF 372. Endpoint devices used to dispense water for drinking must meet the requirements of NSF/ANSI 61, Section 9.

B. Plastic pipe, fittings, and solvent cement shall meet NSF/ANSI 14 and shall be NSF listed for the service intended.

2.2 STAINLESS STEEL

A. Corrosion-resistant Steel (CRS):

1. Plate, Sheet and Strip: CRS flat products shall conform to chemical composition requirements of any 300 series steel specified in ASTM A276.
2. Finish: Exposed surfaces shall have standard polish (ground and polished) equal to NAAMM finish Number 4.

B. Die-cast zinc alloy products are prohibited.

2.3 STOPS

A. Provide lock-shield loose key or screw driver pattern angle stops, straight stops or stops integral with faucet, with each compression type faucet whether specifically called for or not, including sinks in wood and metal casework, laboratory furniture and pharmacy furniture. Locate stops centrally above or below fixture in accessible location.

B. Furnish keys for lock shield stops to COR.

C. Supply from stops not integral with faucet shall be chrome plated copper flexible tubing or flexible stainless steel with inner core of non-toxic polymer.

D. Supply pipe from wall to valve stop shall be rigid threaded IPS copper alloy pipe, i.e. red brass pipe nipple, chrome plated where exposed.

2.4 ESCUTCHEONS

A. Heavy type, chrome plated, with set screws. Provide for piping serving plumbing fixtures and at each wall, ceiling and floor penetrations in exposed finished locations and within cabinets and millwork.

2.5 LAMINAR FLOW CONTROL DEVICE

A. Smooth, bright stainless steel or satin finish, chrome plated metal laminar flow device will provide non-aeration, clear, coherent laminar flow that will not splash in basin. Device will also have a flow control restrictor and have vandal resistant housing.

1. Aerators are prohibited.

B. Flow Control Restrictor:

1. Capable of restricting flow from 32 ml/s to 95 ml/s (0.5 gpm to 1.5 gpm) for lavatories, or as specified.
2. Compensates for pressure fluctuation maintaining flow rate specified above within 10 percent between 170 kPa and 550 kPa (25 psig and 80 psig).
3. Operates by expansion and contraction, eliminates mineral/sediment build-up with self-cleaning action, and is capable of easy manual cleaning.

2.6 CARRIERS

A. ASME/ANSI A112.6.1M, with adjustable gasket faceplate chair carriers for wall hung closets with auxiliary anchor foot assembly, hanger rod support feet, and rear anchor tie down.

B. ASME/ANSI A112.6.1M, lavatory, chair carrier for thin wall construction. All lavatory chair carriers shall be capable of supporting the lavatory with a 250-pound vertical load applied at the front of the fixture.

C. Where water closets, lavatories or sinks are installed back-to-back and carriers are specified, provide one carrier to serve both fixtures in lieu of individual carriers. The drainage fitting of the back to back carrier shall be so constructed that it prevents the discharge from one fixture from flowing into the opposite fixture.

2.7 WATER CLOSETS

A. P-103 Water Closet

1. Fixture: Wall Hung, ASME/ANSI A112.19.2M (Figure 9, office and industrial), elongated bowl, siphon jet 4.85 L (1.28 gallons) per flush, wall outlet.
   a. Accessible water closet shall have rim set 457 mm (18 inches) above finished floor.
   b. Top of rim shall be between 406 mm and 432 mm (16 inches and 17 inches) above finished floor.
2. Seat: Institutional/Industrial, extra heavy duty, chemical resistant, solid plastic, open front less cover for elongated bowls, integrally molded bumpers, concealed check hinge with stainless steel post. Seat shall be posture contoured body design. Color shall be white.
3. Fittings and Accessories: Gaskets-neoprene; bolts with chromium plated caps nuts and washers.

4. Flush valve: Large chloramines resistant diaphragm, semi-red brass valve body, exposed chrome plated,\plain\rtlch\af1\afs22\alang0\ab\ltrch\f1\fs22\lang0\langnp0\langfe0\langfenp0\b non-hold-open ADA approved side oscillating handle 25 mm (1 inch) screwdriver back check angle stop with vandal resistant cap, adjustable tailpiece, a high back pressure vacuum breaker, spud coupling for 38 mm (1 1/2 inches) top spud, wall and spud flanges, and sweat solder adapter with cover tube and set screw wall flange. Valve body, cover, tailpiece and control stop shall be in conformance with ASTM alloy classification for semi-red brass. Seat bumpers shall be integral part of flush valve. Set centerline of inlet 292 mm (11 1/2 inches) above rim.

2.8 LAVATORIES

A. Dimensions for lavatories are specified, Length by width (distance from wall) and depth.

B. Brass components in contact with water shall contain no more than 3 percent lead content by dry weight.

C. P-424 Lavatory

1. Fixture: ASME/ANSI A112.19.2M (Figure 16) straight back, approximately 508 mm by 457 mm (20 inches by 18 inches) and a 102 mm (4 inches) minimum apron, first quality vitreous china, self-rimming, approximately 483 mm x 381 mm (19 inches by 15 inches) oval shape with punching for faucet on 102 mm (4 inches) centers. Mount unit in countertop.
   a. Support countertop with ASME/ANSI A112.19.1M, Type 1, chair carrier with exposed arms.

2. Faucet: Solid cast brass construction with washerless ceramic disc mixing cartridge type and centrally exposed rigid gooseneck spout with outlet 127-152 mm (5-6 inches) above rim. Provide laminar flow control device. One hundred two millimeters (4-inch) wrist blade type handles on faucets shall be cast, formed or drop forged copper alloy. Faucet, wall and floor escutcheons shall be either copper alloy or CRS. Exposed metal parts, including exposed part under valve handle when in open position, shall be chrome plated with a smooth bright finish.
3. Drain: Cast or wrought brass with flat grid strainer and offset tailpiece, chrome plated finish.
4. Stops: Angle type. See paragraph 2.2. Stops
5. Trap: Cast copper alloy, 38 mm by 32 mm (1 1/2 inches by 1 1/4 inches)P-trap. Adjustable with connected elbow and 1.4 mm thick (17 gauge) tubing extension to wall. Exposed metal trap surface, and connection hardware shall be chrome plated with a smooth bright finish. Set trap parallel to wall.
6. Provide cover for drain, stops and trap per A.D.A 4-19.4.

2.9 SINKS AND LAUNDRY TUBS

A. Dimensions for sinks and laundry tubs are specified, length by width (distance from wall) and depth.

B. P-502 Service Sink

1. Fixture: Floor Mounted, stain resistant terrazzo, 711 mm by 711 mm by 305 mm (28 inches by 28 inches by 12 inches) with 152 mm (6 inches) drop front, neo-corner shape. Terrazzo, composed of marble chips and white Portland cement, shall develop compressive strength of 20684 kPa (3000 psi) seven days after casting. Provide extruded aluminum cap on front side.

2. Faucet: Solid brass construction, combination faucet with replaceable monel seat, removable replacement unit containing all parts subject to wear, integral stops, mounted on wall above sink. Spout shall have a pail hook, 19 mm (3/4 inch) hose coupling threads, vacuum breaker, and top or bottom brace to wall. Four-arm handles on faucets shall be cast, formed, or drop forged copper alloy. Escutcheons shall be either forged copper alloy or CRS. Exposed metal parts, including exposed part under valve handle when in open position, shall have a smooth bright finish. Provide 914 mm (36 inches) hose with wall hook. Centerline of rough in is 1219 mm (48 inches) above finished floor.
3. Drain: Seventy six millimeter (3 inches) cast brass drain with nickel bronze strainer.
4. Trap: P-trap, drain through floor.
5. Accessories: Stainless steel wall guards for 2 walls, mop hanger bracket, 30" hose, hose bracket.

2.10 HYDRANT, HOSE BIBB AND MISCELLANEOUS DEVICES

A. P-802 Hose Bibb

1. Fixture: Combination faucet, wall mounted to concealed supply pipes. Cast or wrought copper alloy, combination faucet with replaceable monel seat, removable replacement unit containing all parts subject to wear, mounted on wall 914 mm (36 inches) above floor to concealed supply pipes. Provide faucet without top or bottom brace and with 19 mm (3/4 inch) hose coupling threads on spout, integral stops and vacuum breaker. Design valves with valve disc arranged to eliminate rotation on seat. Four-arm handles on faucets shall be cast, formed or drop forged copper alloy. Escutcheons shall be either forged copper alloy or CRS. Exposed metal parts, including exposed part under valve handle when in open position, shall have a bright finish.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Fixture Setting: Opening between fixture and floor and wall finish shall be sealed as specified under Section 07 92 00, JOINT SEALANTS.

B. Supports and Fastening: Secure all fixtures, equipment and trimmings to partitions, walls and related finish surfaces. Exposed heads of bolts and nuts in finished rooms shall be hexagonal, polished chrome plated brass with rounded tops.
C. Toggle Bolts: For hollow masonry units, finished or unfinished.
D. Expansion Bolts: For brick or concrete or other solid masonry. Shall be 6 mm (1/4 inch) diameter bolts, and to extend at least 76 mm (3 inches) into masonry and be fitted with loose tubing or sleeves extending into masonry. Wood plugs, fiber plugs, lead or other soft metal shields are prohibited.
E. Power Set Fasteners: May be used for concrete walls, shall be 6 mm (1/4 inch) threaded studs, and shall extend at least 32 mm (1 1/4 inches) into wall.
F. Tightly cover and protect fixtures and equipment against dirt, water and chemical or mechanical injury.
G. Where water closet waste pipe has to be offset due to beam interference, provide correct and additional piping necessary to eliminate relocation of water closet.
H. Aerators are prohibited on lavatories and sinks.
I. If an installation is unsatisfactory to the COR, the Contractor will correct the installation at no cost or additional time to the Government.

3.2 CLEANING

At completion of all work, fixtures, exposed materials and equipment shall be thoroughly cleaned.

3.3 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.
B. Components provided under this section of the specification will be tested as part of a larger system.

3.4 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer' s technical representative for two hours to instruct each VA Personnel responsible in operation and maintenance of the system.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

- - - END - - -

SECTION 22 62 00
VACUUM SYSTEMS FOR LABORATORY AND HEALTHCARE FACILITIES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Central Laboratory and Healthcare Vacuum Systems: This section describes the labor, equipment, and services necessary for and incidental to the installation of piped medical vacuum systems. Medical vacuum systems shall be installed started, tested, and ready for use. The scope of work shall include all necessary piping, fittings, valves, cabinets, station outlets and inlets, rough-ins, gauges, alarms (including low voltage wiring), and all necessary parts, accessories, connections, and equipment for a complete and operational system. Match existing station inlet terminal connections.

B. The contractor shall provide all elements and accessories required for a complete system according to the most recent edition of NFPA 99, Gas and Vacuum Systems.

C. All necessary connections to owner furnished equipment shall be made as indicated on the contract documents.

D. Pressure testing, cross connection testing and final testing per NFPA 99 shall be performed.

E. The contractor shall retain a qualified third party medical vacuum verifier acceptable to the engineer of record and VA to perform and attest to final verification of the systems. The contractor shall make all corrections as determined by this third party verifier, including additional testing if necessary to attain full and unqualified certification at no additional time or cost to the Government.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

D. Section 07 84 00, JOINT FIRESTOPPING.

E. Section 07 84 13, PENETRATION FIRESTOPPING.

F. Section 07 92 00, JOINT SEALANTS.

G. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.
H. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.
I. Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.
J. Section 22 63 00, GAS SYSTEMS FOR LABORATORY AND HEALTHCARE FACILITIES.
K. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
L. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES.
M. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS.
N. Section 26 27 26, WIRING DEVICES.

1.3 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the test by the basic designation only.
B. American Society of Mechanical Engineers (ASME):
   1. A13.1-2007 (R2013) Scheme for the Identification of Piping Systems
   2. B16.15-2013 Cast Copper Alloy Threaded Fittings: Classes 125 and 250
   3. B16.22-2013 Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings
   4. B16.50-2013 Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings
   5. B40.100-2013 Pressure Gauges and Gauge Attachments
   6. BPVC Section IX-2015 Welding, Brazing, and Fusing Qualifications
C. American Society of Sanitary Engineers (ASSE):
   1. 6000 Series-2012 Professional Qualifications Standard for Medical Gas Systems Personnel
D. American Society for Testing and Materials (ASTM):
   1. B43-2014 Standard Specification for Seamless Red Brass Pipe, Standard Sizes
   2. B687-1999 (2011) Standard Specification for Brass, Copper, and Chromium-Plated Pipe Nipples
   3. B819-2000 (R2011) Standard Specification for Seamless Copper Tube for Medical Gas Systems

4. D1785-2012 Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120

E. American Welding Society (AWS):
1. A5.8M/A5.8-2011-AMD1 Specification for Filler Metals for Brazing and Braze Welding
2. B2.2/B2.2M-2010 Specification for Brazing Procedure and Performance Qualification

F. Compressed Gas Association (CGA):
1. P-9-2008 The Inert Gases: Argon, Nitrogen, and Helium

G. Manufacturing Standardization Society (MSS):
1. SP-72-2010a Ball Valves with Flanged or Butt-Welding Ends For General Service
2. SP-110-2010 Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends

H. National Electrical Manufacturers Association (NEMA):
1. ICS 6-1993 (R2001, R2006) Industrial Control and Systems Enclosures

I. National Fire Protection Association (NFPA):
1. 70-2021 National Electrical Code
2. 99-2018 Health Care Facilities Code
3. Medical Gas and Vacuum Systems Handbook 2018

1.4 SUBMITTALS

A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 22 62 00, VACUUM SYSTEMS FOR LABORATORY AND HEALTHCARE FACILITIES", with applicable paragraph identification.

C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.
1. Complete specifications for the product intended to be installed and dimensional drawings.

2. Package drawing indicating package style, dimensions when complete, method of disassembly and sizes of subsections for rigging and installation.
3. Piping.
4. Valves.
5. Inlet and outlet cocks.
6. Valve cabinets.
7. Gauges.
8. Station inlets, and rough in assemblies.
9. Alarm controls and panels.
10. Vacuum switches.

D. Station Inlets: A letter from manufacturer shall be submitted stating that inlets are designed and manufactured to comply with NFPA 99. Inlet shall bear label of approval as an assembly, of Underwriters Laboratories, Inc., or Associated Factory Mutual Research Corporation.

E. Certification: The completed systems have been installed, tested, purged and analyzed in accordance with the requirements of this specification. Certification shall be submitted to COR.

F. A notarized affidavit from the verifier stating that the verifier undertakes to verify this project and thus agrees to disqualify themselves from supplying any equipment which shall be included in the scope of their verification. No verifier who supplies equipment shall be permitted to verify that equipment. Statement declaring that the vacuum system manufacturer has no fiduciary interest in the verifier and that the verifier is not an agent or representative of the vacuum system manufacturer. Statement declaring that the contractor has no fiduciary interest in the third party verifier and that the third party verifier has no fiduciary interest in the contractor.

G. Completed System Readiness Checklist provided by the CxA and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

H. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

1.5 QUALITY ASSURANCE

A. Contractor shall include with submittals an affidavit attesting to compliance with all relevant paragraphs of NFPA 99 most recent edition. Personnel assembling medical vacuum and WAGD system shall meet NFPA 99 5.1.10.11.10 “Qualification of Installers” and hold medical gas endorsements as under ASSE Standard Series 6000. The Contractor shall, on company letterhead, furnish documentation attesting that all installed piping materials were purchased cleaned and complied with the requirements of NFPA 99 5.1.10.1 and 5.1.10.2. Electrical Control systems and Medical vacuum Alarms are to be UL listed as assemblies with label affixed. Medical vacuum and WAGD controls are to be wired in accordance with NEC.

B. Equipment Installer: The equipment installer shall provide documentation proving that the personnel installing the equipment meet the standards set by ASSE Standard Series 6000. Show technical qualifications and previous experience in installing medical gas equipment on three similar projects. Submit names, phone numbers, and addresses of referenced projects. The equipment installer shall perform the following coordination functions:

1. Coordinate with other trades to ensure timely installations and avoid conflicts and interferences.
2. Coordinate and field verify with the metal stud partition installer and/or mason to ensure anchors, sleeves and similar items are provided in sufficient time to avoid delays; chases and openings are properly sized and prepared.
3. Coordinate with VA to ensure medical vacuum inlets, whether owner supplied or contractor supplied, in walls, ceiling and all equipment is provided by the same Medical Vacuum Equipment Manufacturer satisfactory to the owner.
4. The contractor shall coordinate with the Medical Vacuum System. Verifier to deliver a complete, operational, and tested medical gas installation ready for owner’s use.

C. Equipment Supplier: The Equipment supplier shall demonstrate evidence of installing equivalent product at three installations similar to this project that has been in satisfactory and efficient operation for three years. Names, phone numbers, and addresses where the product is installed shall be submitted for verification.

D. Medical Gas System Testing Organization: The Medical vacuum verifier shall show documentation proving that the medical gas verifier meets the standards set by ASSE Standard Series 6000. The testing shall be conducted by a party technically competent and experienced in the field of medical gas pipeline testing. Such testing shall be performed by a third party testing company independent of the installing and general contractor.

E. Names of three projects where testing of vacuum systems has been performed by the testing agency shall be provided. The name of the project, names of such persons at that project who supervised the work for the project owner, or who accepted the report for the project owner, and a written statement that the projects listed required work of similar scope to that set forth in this specification shall be included in the documentation.

F. The testing agency's detailed procedure shall be followed in the testing of this project and submitted to COR 10 working days prior to testing. In the testing agency’s procedure documentation, include details of the testing sequence, procedures for cross connection tests, outlet function tests, alarm tests, purity tests, etc., as required by this specification. For purity test procedures, data on test methods, types of equipment to be used, calibration sources and method references shall be submitted.

G. Installation and Startup: The manufacturer shall provide factory authorized representatives to review the installation and perform the initial startup of the system. The factory authorized representatives shall submit a report to the COR and to the Contractor. The Contractor shall make all corrections identified by the factory authorized representative at no additional cost or time to the Government.

H. Certification: The Final inspection documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and certification that all results of tests were within limits allowed by this specification.

I. Bio-Based Materials: For products designated by the USDA's Bio-Preferred Program, provide products that meet or exceed USDA recommendations for bio-based content, so long as products meet all performance requirements in this specifications section. For more information regarding the product categories covered by the Bio-Preferred Program, visit http://www.biopreferred.gov.

1.6 MAINTENANCE SUPPORT

A. The medical vacuum equipment manufacturer shall demonstrate a national factory direct service capability able to perform major overhauls. The medical vacuum equipment manufacturer shall provide factory direct preventative maintenance contract. The medical vacuum equipment manufacturer shall provide formal maintenance training courses. See paragraph "Demonstration and Training" for additional requirements for training. Servicer shall be no more than 100 miles away, be capable of responding within 4 hours, and provide certified personnel to perform all work.

1.7 AS-BUILT DOCUMENTATION

A. Submit manufacturer's literature and data updated to include submittal review comments and any equipment substitutions.

B. Submit operation and maintenance data updated to include submittal review comments, substitutions and construction revisions shall be in electronic version on compact disc or DVD. All aspects of system operation and maintenance procedures, including piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices such as damper and door closure interlocks shall be included. A List of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner shall be required to employ shall be inserted into the As-Built documentation.

C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. As-built drawings are to be provided, and a copy of them in Auto-CAD version 2018 or newer provided on compact disk or DVD. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the 'third party testing company' requirement.

D. Certification documentation shall be provided to COR 10 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and certification that all results of tests were within limits specified.

PART 2 - PRODUCTS

2.1 GENERAL PRODUCT REQUIREMENTS

A. A single Medical Vacuum Equipment Manufacturer shall supply the medical vacuum system(s) and equipment to include outlets, valves and gauges, valve boxes, alarm panels, manifolds, medical air, instrument air, vacuum and WAGD sources.

2.2 PIPING

A. Copper Tubing: Copper tubing shall be type "K" or "L", ASTM B819, seamless copper tube, hard drawn temper, with wrought copper fittings conforming to ASME B16.22 or brazing fittings complying with ASME B16.50. The copper tubing size designated reflects nominal inside diameter. All tubing and fittings shall be labeled "ACR/OXY", "OXY", "OXY/MED", "ACR/MED", or "MED".

B. Brazing Alloy: The brazing alloy shall comply with AWS A5.8M/A5.8, Classification BCuP, greater than 538 degrees C (1000 degrees F) melting temperature. Flux shall be strictly prohibited for copper to copper connections.

C. Screw Joints: Screw joints shall use polytetrafluoroethylene (Teflon) tape.

D. Use only copper or stainless steel pipes for discharge from vacuum product (exhaust pipes).

E. Memory metal couplings shall have temperature and pressure ratings not less than that of a brazed joint.

F. Piping identification labels shall be applied at time of installation in accordance with NFPA 99. Supplementary color identification shall be in accordance with CGA Pamphlet C-9.

G. Special Fittings: The following special fittings shall be permitted to be used in lieu of brazed joints:

1. Memory-metal couplings having temperature and pressure ratings joints not less than that of a brazed joint.
2. Listed or approved metallic gas tube fittings that, when made up, provide a permanent joint having the mechanical, thermal, and sealing integrity of a brazed joint.
3. Dielectric fittings where required by the manufacturer of special medical equipment to electrically isolate the equipment from the piping distribution system.
4. Axially swaged, elastic strain preload fittings providing metal to metal seal having pressure and temperature ratings not less than that of a brazed joint and when complete are permanent and non-separable.

2.3 VALVES

A. Ball: Ball valves shall be in line, other than zone valves in cabinets.
   1. 65 mm or DN65 (2-1/2 inches) and less: Ball valves shall be bronze/ brass body, MSS SP-72 and MSS SP-110, Type II, Class 150, Style 1, with tubing extensions for brazed connections, full ported, three piece or double union end connections, Teflon seat seals, full flow, 4138 kPa (600 psig) WOG minimum working pressure, with locking type handle.
   2. 75 mm or DN75 to 100 mm or DN100 (3 to 4 inches): Ball valves shall be bronze/ brass body, MSS SP-72 and MSS SP-110, Type II, Class 150, Style 1 with tubing extensions brazed to flanges, full ported, three piece, double seal, Teflon seals, full flow, 4138 kPa (600 psig) WOG minimum working pressure, with locking type handle.

B. Check:
   1. 75 mm or DN75 (3 inches) and less: Check valves shall be brass and bronze body, straight through design for minimum pressure drop, spring loaded, self-aligning with Teflon cone seat, vibration free, silent operation, supplied NPT female threads at each end with flow direction arrow permanently cast into body, 2758 kPa (400 psig) WOG minimum working pressure.
   2. 100 mm or DN100 (4 inches) and greater: Check valves shall be iron body, bronze trim, swing type, vertical or horizontal installation, flange connection, 1035 kPa (150 psig) WSP with flow direction arrow permanently cast into body.

C. Zone valve in cabinet shall be ball valve with bronze/ brass body, double seal, three piece or double union end connections, replaceable Teflon seat seals, Teflon stem seal, 4138 kPa (600 psig) WOG, cold, non-shock gas working pressure or vacuum service to 100 kPa (29.5 inches Hg), blowout proof stem, one quarter turn of handle to completely open or close. Tubing extensions, factory brazed, pressure tested, cleaned for oxygen service shall be provided. A 3.2 mm (1/8 inch) NPT gauge port shall be provided for a 50 mm (2 inch) diameter monitoring gauge downstream of the shut-off valve. Zone valves shall be securely attached to the cabinet and provided with type“K” copper tube extensions for making connection to system piping outside the cabinet. Zone valves shall be products of one manufacturer, and uniform throughout in pattern, overall size and appearance. Trim with color coded plastic inserts or color coded stick on labels. Valves shall be in cabinets such that cover window cannot be in place when any valve is in the closed position. Color coding for identification plates and labels is as follows:

1. Medical Vacuum: Black letters on white background

2.4 VALVE CABINETS

A. Valve cabinets shall be flush mounted, commercially available item for use with medical gas services, constructed from steel not lighter than 1.3 mm (18 gage) steel or extruded aluminum not lighter than 1.9 mm (14 gage). The valve cabinets shall be rigidly assembled, of adequate size to accommodate all valve(s) and fittings indicated. Holes shall be predrilled to receive pipe connections. These pipe connections shall be made outside of the valve box. Anchors shall be provided to secure cabinet to wall construction. Openings in cabinet shall be sealed to be dust tight. Bottom of cabinet shall be located 1375 mm (4 foot 6 inches) above finished floor.

B. Engraved rigid plastic identification plate shall be mounted on the wall above or adjacent to the cabinet. Color code identification plate to match gas identification colors as indicated above. Identification plate shall be clearly visible at all times. Inscriptions shall be provided on plate to read in substance: "VALVE CONTROL SUPPLY TO ROOMS." The final wording shall be approved by the COR or VA facility.

C. Cover plate: The cover plate shall be fabricated from 1.3 mm (18 gage) sheet metal with satin chromed finish, extruded anodized aluminum, or 0.85 mm (22 gage) stainless steel. A cover window shall be provided of replaceable plastic, with a corrosion resistant device or lever secured to window for emergency window removal. The following shall be permanently painted or stenciled on window: "FOR EMERGENCY SHUT-OFF VALVES ONLY, SHUT-OFF VALVES FOR PIPED GASES", or equivalent wording. The valve cabinet shall be configured such that it is not possible to install window with any valve in the closed position. Each valve shall have a pressure gauge upstream of valve and this pressure gage shall be inside valve box.

D. Cabinets and isolation valves shall be located and piped as shown on the contract documents, and at a minimum, so as to allow the isolation of each smoke compartment separately. Each cabinet shall serve no more than one smoke compartment.

2.5 GAGES

A. Vacuum Gages:

1. For vacuum line adjacent to source equipment the vacuum gages shall comply with ASME B40.100, vacuum gage type, size 115 mm (4-1/2 inches), gage listed for vacuum, accurate to within 2-1/2 percent, with metal case. The vacuum gage range shall be 0 to 100 kPa (0 to 29.5 inches Hg). Dial graduations and figures shall be black on a white background, or white on a black background. Label shall be for vacuum service. A gage cock shall be installed. Dual scale gages shall be installed for vacuum system.
2. For vacuum service upstream of main shut-off valve: A 40 mm (1-1/2 inches) diameter gage shall be provided with steel case, bourdon tube and brass movement, dial range 0 to 100 kPa (0 to 29.5 inches Hg). Dual scale gages shall be provided for vacuum system.

2.6 STATION INLETS

A. Vacuum Station inlets:

1. Station inlets shall be for designated service, consisting of a quick coupler, quick disconnect type with inlet supply tube.

2. The outlet station shall be made, cleaned, and packaged to NFPA 99 standards and shall be UL listed and CSA certified.
3. A coupler shall be provided that is non-interchangeable with other services, and leak proof under three times normal working pressure.
4. Each station inlet shall be equipped with an automatic valve to conform with NFPA 99. Valves shall be placed in the assembly to provide easy access after installation for servicing and replacement, and to facilitate line blow-out, purging, and testing.
5. Each inlet shall be securely fastened to structure and provide each with a capped stub length of 7 mm (1/4 inches) (10 mm outside diameter) (3/8 inches outside diameter) tubing for connection to supply tubing. Stub tubing shall be labeled for appropriate service. Rough in shall be indexed and gas specified latch valve with non-interchangeable safety keying with color coded gas service identification.
6. Rough-in kits and test plugs for PBPU shall be furnished under this specification but installed by manufacturer of PBPU before initial test specified herein.
7. Completion kits (valve body and face plate) shall be installed for the remainder of required tests.

2.7 STATION INLET ROUGHIN

A. Station inlet rough in shall be flush mounted, and protected against corrosion. Rough in shall be anchored securely to unit or wall construction.

B. The modular cover plate shall be constructed from die cast plate, two piece 0.85 mm (22 gage) stainless steel or 1.6 mm (16 gage) chromium plated metal, secured to rough in with stainless steel or chromium plated countersunk screws. The latch mechanism shall be designed for one handed, single thrust mounting and one handed fingertip release of secondary equipment.

C. Cover Plate for PBPU shall be one piece with construction and material as indicated for modular cover plate.

D. Permanent, metal or plastic, identification plates shall be provided securely fastened at each inlet opening, with inscription for appropriate service using color coded letters and background. Metal plates shall have letters embossed on baked on enamel background. Color coding for identification plates is as follows:
   1. Medical Vacuum: Black letters on white background

2.8 VACUUM SWITCHES

A. Vacuum switches shall be general purpose, contact or mercury type, allowing both high and low set points, with contact type provided with a protective dust cover. The vacuum switch shall have an adjustable range set by inside or outside adjustment. Vacuum switches shall activate when indicated by alarm requirements. One orifice nipple (or DISS demand check valve) shall be used for each sensor switch.

PART 3 - EXECUTION

3.1 INSTALLATION

A. All installation shall be performed in strict accordance with NFPA 99 5.1.10. Brazing procedures shall be as detailed in NFPA 99 5.1.10.4. Brazing shall be performed only by brazers qualified under NFPA 99 5.1.10.11.10. Where piping runs underground, the installation shall be made in accordance with NFPA 99 5.1.10.11.5.
B. Contractor shall furnish 100 mm (4 inches) high concrete housekeeping pads. The contractor shall furnish inertia bases in lieu of housekeeping pads where the equipment installed is not factory isolated by the manufacturer. Anchor bolts shall be cast into bases
C. Cast escutcheon shall be installed with set screw at each wall, floor and ceiling penetration in exposed finished locations and within cabinets and millwork.
D. Open ends of tube shall be capped or plugged at all times or otherwise sealed until final assembly to prevent infiltration of any foreign matter.

E. Piping shall be cut square and accurately with a tube cutter (sawing is prohibited) to measurements determined at place of installation. The tubing shall be reamed to remove burrs, being careful not to expand tube, and so no chips of copper remain in the tube. The tubing shall be worked into place without springing or forcing. The tubing shall be bottomed in socket so there are no gaps between tube and fitting. Care shall be exercised in handling equipment and tools used in cutting or reaming of tube to prevent oil or grease from being introduced into the tubing. Where contamination has occurred, material shall be no longer suitable for vacuum service and new, sealed tube sections used.

F. Piping shall be supported with pipe trays or hangers at intervals as shown on the contract drawings or as defined in NFPA 99. Piping shall not be supported by other piping. Isolation of copper piping from dissimilar metals shall be of a firm, positive nature. Duct tape is prohibited as an isolation material.

G. Valves and other equipment shall be rigidly supported to prevent strain on tube or joints.

H. Piping exposed to physical damage shall be protected.

I. During any brazing operation, the interior of the pipe shall be purged continuously with oil free, dry nitrogen NF, following the procedure in NFPA 99 5.1.10.4.5. At the completion of any section, all open pipe ends shall be capped using an EXTERNAL cap. The flow of purged gas shall be maintained until joint is cool to touch. The use of flux is prohibited when making of joints between copper to copper pipes and fittings.

J. Threaded joints in piping systems shall be avoided whenever possible. Where unavoidable, make up the male threads with polytetrafluoroethylene (such as Teflon) tape. Liquid sealants are prohibited.

K. Tubing shall not be bent. Fittings shall be used in all change of direction or angle.

L. After installation of the piping, but before installation of the outlet valves, blow lines clear using nitrogen NF per NFPA 99.

M. Ceiling column assembly shall be supported from heavy sub-mounting castings and furnished with the unit as part of rough in. Ceiling columns shall be anchored with 15 mm (1/2 inch) diameter bolts attached to angle iron frame supported from structural ceiling.

N. Two 25 mm (1 inch) minimum conduits shall be provided from ceiling column assembly to the adjacent corridor, one for mass spectrometer tubing and wiring and one for monitor wiring, and for connection to signal cabling network.

O. Pressure and vacuum switches, transmitter and gauges shall be installed to be easily accessed, and provide access panel where installed above plaster ceiling. Pressure switch and sensors shall be installed with orifice nipple between the pipe line and switches/sensors.

P. Pipe labeling shall be applied during installation process and not after installation is completed. Size of legend letters shall be in accordance with ASME A13.1.

Q. After initial leakage testing is completed, the piping shall be allowed to remain pressurized with testing gas until testing agency performs final tests.

R. Penetrations:

1. Fire Stopping: Where pipes pass through fire partitions, fire walls, smoked partitions, or floors, fire stopping shall be installed that provides an effective barrier against the spread of fire, smoke and gases as specified in Section 07 84 00, FIRESTOPPING, Clearances between raceways and openings with the fire stopping material shall be completely filled and sealed.
2. Water proofing: At floor penetrations, clearances shall be completely sealed around the pipe and made watertight with sealant as specified in Section 07 92 00, JOINT SEALANTS.

S. A vacuum gage 40 mm (1-1/2 inch) diameter shall be installed in line downstream of each valve located in a zone valve cabinet.

T. Zone valves shall be provided in cabinets where indicated and outside each Operating Room and a minimum one zone valve assembly for each 18 outlets.

U. Piping shall be labeled with name of service, identification color and direction of flow. Where non-standard pressures are piped, pressure shall be labeled. Labels shall be placed at least once every 6.1 m (20 feet) of linear run or once in each story (whichever is more frequent). A label shall additionally be placed immediately on each side of all wall or floor penetrations. Pipe labels shall be self adhesive vinyl type or other water resistant material with permanent adhesive colored in accordance with NFPA 99 Table 5.1.11 and shall be visible on all sides of the pipe. Each master alarm signal shall be labeled for function after ring out. Each zone valve shall be labeled and each area alarm labeled for the area of control or surveillance after test. Labels shall be permanent and of a type approved by the VAMC.

V. Alarms and valves shall be labeled for service and areas monitored or controlled. Coordinate with the VAMC for final room or area designations. Valves shall be labeled with name and identification color of the gas and direction of flow.

3.2 INSTALLER TESTING

A. Prior to declaring the lines ready for final verification, the installing contractor shall strictly follow the procedures for verification as described in NFPA 99 5.1.12.2 and attest in writing over the notarized signature of an officer of the installing company the following;

1. That all brazing was conducted by brazers qualified to ASSE Standard Series 6000 and holding current medical gas endorsements.
2. That all brazing was conducted with nitrogen purging. (Procedure per NFPA 99 5.1.10.4.5).
3. That the lines have been blown clear of any construction debris using oil free dry nitrogen or air are clean and ready for use. (Procedure per NFPA 99 5.1.12.2.2).
4. That the assembled piping, prior to the installation of any devices, maintained a test pressure 1 1/2 times the standard pressures listed in NFPA 99 Table 5.1.11 without leaks. (Procedure per NFPA 99 5.1.12.2.3).

5. That after installation of all devices, the pipeline was proven leak free for 24 hours at a pressure 20 percent above the standard pressures listed in NFPA 99 Table 5.1.11. (Procedure per NFPA 99 5.1.12.2. 6)
6. That the systems have been checked for cross connections and none were found. (Procedure per NFPA 99 5.1.12.2.4)

B. Four originals of the affidavit, shall be distributed; (2) to the COR, (1) to the general contractor, and (1) to the verifier (www.mgpho.org).

3.3 VERIFIER TESTING

A. Prior to handing over the systems to VAMC, the contractor shall retain a verifier acceptable to the engineer of record and VA who shall follow strictly the procedures for verification as described in NFPA 99 5.1.12.3 and provide a written report and certificate bearing the notarized signature of an officer of the verification company on company letterhead which contains at least the following:
   1. A current ACORD insurance certificate indicating professional liability coverage in the minimum amount of $1 Million per occurrence, and general aggregate liability in the minimum amount of $1 Million, valid and in force when the project is to be verified. General liability insurance alone is not acceptable.
   2. An affidavit bearing the notarized signature of an officer of the verification company stating that the verification company is not the supplier of any equipment used on this project or tested in this report and that the verification contractor has no relationship to, or pecuniary interest in, the manufacturer, seller, or installer of any equipment used on this project or tested in this report.
   3. A listing of all tests performed, listing each source, outlet, valve and alarm included in the testing.

4. An assertion that all tests were performed by a Medical Vacuum System Certified Medical Gas or vacuum Verifier or by individuals qualified to perform the work and holding valid qualifications to ASSE 6030 and under the immediate supervision a Verifier. Include the names, credential numbers and expiration dates for all individuals working on the project.
5. A statement that equipment used was calibrated at least within the last six months by a method traceable to a National Bureau of Standard Reference and enclosing certificates or other evidence of such calibration(s). Where outside laboratories are used in lieu of on site equipment, those laboratories shall be named and their original reports enclosed.
6. A statement that where and when needed, equipment was re calibrated during the verification process and describing the method(s) used.
7. A statement that the systems were tested and found to be free of debris to a procedure per NFPA 99 5.1.12.3.7.
8. The flow from each outlet when tested to a procedure per NFPA 99 5.1.12.3.10.
9. A statement that the systems were tested and found to have no cross-connections to a procedure per NFPA 99 5.1.12.3.3.
10. A statement that the systems were tested and found to be free of contaminants to a procedure per NFPA 99 5.1.12.3.8 except that the purity standard shall be 2 ppm difference for halogenated hydrocarbons and 1 ppm total hydrocarbons (as methane).
11. Statement that all local signals function as required under NFPA 99 5.1.3.5.8 and as per the relevant NFPA 99 sections relating to the sources.
12. A listing of local alarms, their function and activation per NFPA 99 5.1.12.3.14.
13. A listing of master alarms, their function and activation, including pressures for high and low alarms per NFPA 99 5.1.12.3.5.2.
14. A listing of area alarms, their function and activation pressures per NFPA 99 5.1.12.3.5.3.

15. A statement that the sources include all alarms required by NFPA 99 Table A.5.1.9.5.
16. The concentration of each component of NFPA 99 Table 5.1.12.3.11 in the medical air after 24 hours of operation of the medical air source.
17. The concentration of each gas at each outlet as specified in NFPA 99 5.1.12.3.11.
18. A statement that all valves and alarms are accurately labeled as to zone of control.

B. Perform and document all cross connection tests, labeling verification, supply system operation, and valve and alarm operation tests as required by, and in accordance with NFPA 99 and the procedures set forth in pre-qualification documentation.

C. Verify that the systems, as installed, meet or exceed the requirements of NFPA 99, this specification, and that the systems operate as required.

D. Piping purge test: For each positive pressure gas system, verify cleanliness of piping system. Filter a minimum of 1000 liters (35 cubic feet) of gas through a clean white 0.45 micron filter at a minimum velocity of 100 mps (3.5 fpm). Filter shall show no discoloration, and shall accrue no more than 0.1 mg of matter. Test each zone at the outlet most remote from the source. Perform test with the use of an inert gas as described in CGA P-9. Retest until all tests pass at no additional time or cost to the Government.

E. Inlet flow test:
   1. Test all inlets for flow. Perform test with the use of an inert gas as described in CGA P-9.
   2. Needle valve vacuum inlets shall draw no less than 1.0 SCFM with adjacent inlet flowing, at a dynamic inlet pressure of 40 kPa (12 inches Hg), and a static vacuum of 10 kPa (3 inches Hg).
   3. Vacuum inlets shall draw no less than 85 Lpm (3.0 SCFM) with adjacent inlet flowing, at a dynamic inlet pressure of 40 kPa (12 inches Hg), and a static vacuum of 50 kPa (15 inches Hg).

4. Anesthesia evacuation inlets shall draw no less than 1 L/mm (1.0 SCFM) at a dynamic inlet pressure of 40 kPa (12 inches Hg), and a static vacuum of 50 kPa (15 inches Hg).

3.4 CONNECTION TO EXISTING LABORATORY VACUUM SYSTEM

A. Contactor shall test the existing system for hydrocarbons, dew point, etc. per NFPA 99. If problems are present, the COR would notify the facility of the results. The facility would then make the necessary repairs and/or maintenance.

B. Double shut-off valves shall be installed at the connection of new line to existing line.

C. Time for shutdown of the existing vacuum system shall be coordinated at least 10 work days prior to shutdown with the COR and VA Medical Center.

D. Prior to any work being done, new pipeline shall be checked for particulate or other forms of contamination per NFPA 99.

E. Ensure that the correct type of pipe tubing and fittings are being used.

F. A spot check of the existing pipelines shall be made in the facility to determine the level of cleanness present.

G. The tie-in shall be made as quickly as possible. A nitrogen purge is not required since this would require another opening in the pipe.

H. After the tie-in is made and allowed to cool, slowly bleed the source vacuum back into the pipeline. Test the work area for leaks with soapy water and repair any leaks.

I. After all leaks, if any, are repaired and the line is fully recharged, perform blow down and testing. Open the zone that is closest to the main to the system, access the closest outlet to the work, and blow the main through the inlet. After the inlet blows clear into a white cloth, make an additional check at a zone most distant from the work. Perform all required NFPA 99 tests after connection.

3.5 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

B. Components provided under this section of the specification will be tested as part of a larger system.

3.6 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer’s technical representative for four hours to instruct VA Personnel in operation and maintenance of the system.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

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SECTION 22 63 00
GAS SYSTEMS FOR LABORATORY AND HEALTHCARE FACILITIES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Central Laboratory and Healthcare Gas Systems: Consisting of oxygen, nitrous oxide, and medical air services; complete, ready for operation, including all necessary piping, fittings, valves, cabinets, station outlets, rough-ins, gauges, alarms (including low voltage wiring), and all necessary parts, accessories, connections, and equipment. Match existing station outlet and inlet terminal connections.

B. Laboratory and healthcare gas system alarm wiring from equipment to alarm panels.

C. The contractor shall retain a qualified third party medical gas system verifier acceptable to the engineer of record and VA to perform and attest to final verification of the systems. The contractor shall make all corrections as determined by this third party verifier, including additional testing if necessary to attain full and unqualified certification at no additional time or cost to the Government.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

D. Section 07 84 00, JOINT FIRESTOPPING.

E. Section 07 84 13, PENETRATION FIRESTOPPING.

F. Section 07 92 00, JOINT SEALANTS.

G. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

H. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

I. SECTION 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

J. SECTION 22 62 00, VACUUM SYSTEMS FOR LABORATORY AND HEALTHCARE FACILITIES.

K. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

L. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES.

M. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS.

N. Section 26 27 26, WIRING DEVICES.

1.3 APPLICABLE PUBLICATIONS

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

B. American Society of Mechanical Engineers (ASME):

1. A13.1-2007 (R2013) Scheme for the Identification of Piping Systems
2. B16.15-2013 Cast Copper Alloy Threaded Fittings: Classes 125 and 250
3. B16.22-2013 Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings
4. B16.50-2013 Wrought Copper and Copper Alloy Braze-Joint Pressure Fittings
5. B40.100-2013 Pressure Gauges and Gauge Attachments
6. ASME Boiler and Pressure Vessel Code
7. BPVC Section VIII-2015 Rules for Construction of Pressure Vessels, Division I
8. BPVC Section IX-2015 Welding, Brazing, and Fusing Qualifications
9. American Society of Sanitary Engineers (ASSE):
10. 6000 Series-2012 Professional Qualifications Standard for Medical Gas Systems Personnel

C. American Society for Testing and Materials (ASTM):

1. B43-2014 Standard Specification for Seamless Red Brass Pipe, Standard Sizes
2. B687-1999 (2011) Standard Specification for Brass, Copper, and Chromium-Plated Pipe Nipples
3. B819-2000 (R2011) Standard Specification for Seamless Copper Tube for Medical Gas Systems
4. D1785-2012 Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120

D. American Welding Society (AWS):

1. A5.8M/A5.8-2011 Specification for Filler Metals for Brazing and Braze Welding
2. B2.2/B2.2M-2010 Specification for Brazing Procedure and Performance Qualification

E. Compressed Gas Association (CGA):
   1. C-9-2013 Standard Color Marking of Compressed Gas Containers for Medical Use
   2. G-4.1-2009 Cleaning Equipment for Oxygen Service
   3. G-10.1-2008 Commodity Specification for Nitrogen
   4. P-9-2008 The Inert Gases: Argon, Nitrogen, and Helium
   5. V-1-2013 Standard for Compressed Gas Cylinder Valve Outlet and Inlet Connections

F. Manufacturing Standardization Society (MSS):
   1. SP-72-2010a Ball Valves With Flanged or Butt-Welding Ends For General Service
   2. SP-110-2010 Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends

G. National Electrical Manufacturers Association (NEMA):
   1. ICS 6-1993 (R2001, R2006) Industrial Control and Systems Enclosures

H. National Fire Protection Association (NFPA):
   1. 99-2018 Health Care Facilities Code
   2. Medical Gas and Vacuum Systems Handbook 2018

1.4 SUBMITTALS

A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 22 63 00, GAS SYSTEMS FOR LABORATORY AND HEALTHCARE FACILITIES", with applicable paragraph identification.

C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.
   1. Piping.
   2. Valves.
   3. Inlet and outlet cocks.
   4. Valve cabinets.
   5. Gauges.

6. Station outlets and roughin assemblies.
7. Alarm controls and panels.
8. Pressure Switches.

D. Station Outlets: Submit letter from manufacturer stating that outlets are designed and manufactured to comply with NFPA 99. Outlet shall bear label of approval as an assembly, of Underwriters Laboratories, Inc., or Associated Factory Mutual Research Corporation.

E. Certification: The completed systems have been installed, tested, purged, analyzed and verified in accordance with the requirements of this specification. Certification shall be submitted to COR.

F. Completed System Readiness Checklist provided by the CxA and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

G. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

1.5 QUALITY ASSURANCE

A. Materials and Installation: In accordance with NFPA 99 and as specified.

B. Equipment Installer: Show technical qualifications and previous experience in installing laboratory and healthcare equipment on three similar projects. Submit names, phone numbers, and addresses of referenced projects. Installers shall meet the qualifications of ASSE Standard Series 6000.

C. Equipment Supplier: Provide evidence of equivalent product installed at three installations similar to this project that has been in satisfactory and efficient operation for three years. Submit names, phone numbers, and addresses where the product is installed.

D. Laboratory and healthcare System Testing Organization: The testing shall be conducted by a party technically competent and experienced in the field of laboratory and healthcare pipeline testing. Testing and systems verification shall be performed by personnel meeting the qualifications of ASSE Standard Series 6000. Such testing shall be performed by a party other than the installing contractor.

E. Provide the names of three projects where testing of medical or laboratory gases systems has been performed by the testing agency. Include the name of the project, names of such persons at that project who supervised the work for the project owner, or who accepted the report for the project owner, and a written statement that the projects listed required work of similar scope to that set forth in this specification.

F. Submit the testing agency's detailed procedure which shall be followed in the testing of this project. Include details of the testing sequence, procedures for cross connection tests, outlet function tests, alarm tests, purity tests, etc., as required by this specification. For purity test procedures, include data on test methods, types of equipment to be used, calibration sources and method references.

G. Certification: Provide COR documentation 10 working days prior to submitting request for final inspection to include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and certification that all results of tests were within limits allowed by this specification.

H. “Hot taps” are prohibited for operating medical oxygen systems. Methods for connection and extension of active and pressurized medical gas systems without subsequent medical gas testing and verification are prohibited.

I. Bio-Based Materials: For products designated by the USDA’s Bio-Preferred Program, provide products that meet or exceed USDA recommendations for bio-based content, so long as products meet all performance requirements in this specifications section. For more information regarding the product categories covered by the Bio-Preferred Program, visit http://www.biopreferred.gov.

1.6 AS-BUILT DOCUMENTATION

A. Submit manufacturer’s literature and data updated to include submittal review comments and any equipment substitutions.

B. Submit operation and maintenance data updated to include submittal review comments, substitutions and construction revisions shall be in electronic version on compact disc or DVD. All aspects of system operation and maintenance procedures, including piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices such as damper and door closure interlocks shall be included. A List of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.

C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. As-built drawings are to be provided, and a copy of them in Auto-CAD version 2018 or newer provided on compact disk or DVD. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the ' third party testing company' requirement.

D. Certification documentation shall be provided to COR 10 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and certification that all results of tests were within limits specified.

PART 2 - PRODUCTS

2.1 PIPING AND FITTINGS

A. Copper Tubing: Type "K", ASTM B819, seamless copper tube, hard drawn temper, with wrought copper fittings conforming to ASME B16.22 or brazing fittings complying with ASME B16.50. Size designated reflecting nominal inside diameter. All tubing and fittings shall be labeled "ACR/OXY", "OXY", "OXY/MED", "ACR/MED", or "MED".

B. Brazing Alloy: AWS A5.8M/A5.8, Classification BCuP, greater than 538 degrees C (1000 degrees F) melting temperature. Flux is strictly prohibited for coppertocopper connections.

C. Threaded Joints: Polytetrafluoroethylene (Teflon) tape.

D. Memory metal couplings: Temperature and pressure rating shall not be less than that of a brazed joint in accordance with NFPA 99, paragraph 5.1.10.6.1.

E. Apply piping identification labels at the time of installation in accordance with NFPA 99. Apply supplementary color identification in accordance with CGA Pamphlet C-9.

F. Special Fittings: The following special fittings shall be permitted to be used in lieu of brazed joints:

1. Memory-metal couplings having temperature and pressure ratings joints not less than that of a brazed joint.
2. Listed or approved metallic gas tube fittings that, when made up, provide a permanent joint having the mechanical, thermal, and sealing integrity of a brazed joint.
3. Dielectric fittings where required by the manufacturer of special medical equipment to electrically isolate the equipment from the piping distribution system.
4. Axially swaged, elastic strain preload fittings providing metal to metal seal having pressure and temperature ratings not less than that of a brazed joint and when complete are permanent and non-separable.

2.2 VALVES

A. Ball: In-line, other than zone valves in cabinets:

1. 75 mm (3 inches) and smaller: Bronze/ brass body, MSS SP-72, MSS SP110, Type II, Class 150, Style 1, with tubing extensions for brazed connections, full port, threepiece or double union end connections, Teflon seat seals, full flow, 4138 kPa (600 psig) WOG minimum working pressure, with locking type handle, cleaned for oxygen use and labeled for intended service.
2. 75 to 100 mm (3 to 4 inches): Bronze/ brass body, MSS SP-72 MSS SP110, Type II, Class 150, Style 1 with tubing extensions brazed to flanges, full port, three piece, double seal, Teflon seals, full flow, 4138 kPa (600 psig) WOG minimum working pressure, with locking type handle, cleaned for oxygen use and labeled for intended service.

B. Check:
1. 75 mm (3 inches) and smaller: Bronze/brass body, straight through design for minimum pressure drop, spring loaded, self-aligning with Teflon cone seat, vibration free, silent operation, supplied NPT female threads at each end with flow direction arrow permanently cast into, cleaned for oxygen use and labeled for intended service, 2758 kPa (400 psig) WOG minimum working pressure.
2. 100 mm (4 inches) and larger: Iron body, bronze trim, swing type, vertical or horizontal installation, flange connection, with flow direction arrow permanently cast into, cleaned for oxygen use and labeled for intended service, 1035 kPa (150 psig) WSP.

C. Zone Valve in Cabinet: Ball valve, bronze/ brass body, double seal, three piece or double union end connections, replaceable Teflon seat seals, Teflon stem seal, 4138 kPa (600 psig) WOG, cold, nonshock gas working pressure service to 100 kPa (29 inches Hg), cleaned for oxygen use and labeled for intended service, blowout proof stem, one quarter turn of handle to completely open or close. Provide tubing extensions factory brazed, and pressure tested. Provide 3.2 mm (1/8 inch) NPT gauge port for a 50 mm (2 inch) diameter monitoring gauge downstream of the shut off valve. Zone valves shall be securely attached to the cabinet and provided with type "K" copper tube extensions for making connection to system piping outside the cabinet. Zone valves shall be products of one manufacturer, and uniform throughout in pattern, overall size and appearance. Trim with color coded plastic inserts or color coded stickon labels. Install valves in cabinets such that cover window cannot be in place when any valve is in the closed position. Color coding for identification plates and labels is as follows:
   1. Oxygen: White letters on green background.
   2. Nitrous Oxide: White letters on blue background.
   3. Nitrogen: White letters on black background.
   4. Medical Air: Black letters on yellow background.
   5. Carbon Dioxide: Black or white letters on gray background.

2.3 VALVE CABINETS

A. Flush mounted commercially available item for use with laboratory and healthcare services, not lighter than 1.3 mm (18 gage) steel or 1.9 mm (14 gage) extruded aluminum, rigidly assembled, of adequate size to accommodate valve(s) and fittings. Punch or drill sides to receive tubing. Provide anchors to secure cabinet to wall construction. Seal openings in cabinet to be dust tight. Locate bottom of cabinet 1375 mm (4 feet 6 inches) above finished floor.

B. Mount engraved rigid plastic identification plate on wall above or adjacent to cabinet. Color code identification plate to match gas identification colors as indicated above. Identification plate shall be clearly visible at all times. Provide inscriptions on plate to read in substance: "VALVE CONTROL SUPPLY TO ROOMS."

C. Cover plate: Fabricate from 1.3 mm (18 gage) sheet metal with satin chromed finish, extruded anodized aluminum, or 0.85 mm (22 gage) stainless steel. Provide cover window of replaceable plastic, with a corrosion resistant device or lever secured to window for emergency window removal. Permanently paint or stencil on window: CAUTION-CLOSE ONLY IN EMERGENCY, SHUTOFF VALVES FOR PIPED GASES", or equivalent wording. Configure such that it is not possible to install window with any valve in the closed position. Each valve shall have gauge upstream of valve inside valve box.

D. Cabinets and isolation valves shall be located and piped as shown on drawings, and at a minimum, so as to allow the isolation of each smoke compartment separately. No cabinet shall serve more than one smoke compartment.

2.4 GAUGES

A. Pressure Gages: Includes gages temporarily supplied for testing purposes.

B. For line pressure use adjacent to source equipment: ASME B40.1, pressure gage, single, size 115 mm (41/2 inches), for compressed air, nitrogen and oxygen, accurate to within 2 percent, with metal case. Range shall be two times operating pressure. Dial graduations and figures shall be black on a white background, or white on a black background. Gage shall be cleaned for oxygen use, labeled for appropriate service, and marked "USE NO OIL". Install with gage cock.

C. For all services downstream of main shutoff valve:
   1. Manufactured for oxygen use, labeled for the appropriate service and marked "USE NO OIL", 40 mm (11/2 inch) diameter gage.
   2. Dial range 1 to 690 kPa (1 to 100 psig) for air service.
   3. Dial range 1 to 690 kPa (1 to 100 psig).

2.5 STATION OUTLETS

A. For all services except ceiling hose drops: For designated service, consisting of a quick coupler and inlet supply tube. Provide coupler that is non-interchangeable with other services, and leak proof under three times the normal working pressure. Equip each station outlet with an automatic valve and a secondary check valve to conform with NFPA 99. Equip each station inlet with an automatic valve to conform with NFPA 99. Place valves in the assembly to provide easy access after installation for servicing and replacement, and to facilitate line blow-out, purging, and testing. Fasten each outlet and inlet securely to rough-in to prevent floating and provide each with a capped stub length of 6 mm (1/4-inch) (10 mm outside diameter) (3/8-inch outside diameter) tubing for connection to supply. Identification of each gas service shall be permanently cast into the back plate and shall be visible through a transparent plastic guard. Label stub tubing for appropriate service. Rough-in kits and test plugs for PBPU are furnished under this specification but installed by manufacturer of PBPU before initial test specified herein. Install completion kits (valve body and face plate) for the remainder of required tests.

2.6 STATION OUTLET ROUGH-IN

A. Anchor flush mounted rough-in securely to unit or wall construction.

B. Modular Cover Plate: Die cast back plate, twopiece 0.85 mm (22 gage) stainless steel or 1.6 mm (16 gage) chromium plated metal, with mounting flanges on all four sides, secured to roughin with stainless steel or chromium plated countersunk screws.

C. Cover Plate for PBPU: Onepiece with construction and material as indicated for modular cover plate.

D. Provide permanent, metal or plastic, identification plates securely fastened at each outlet and inlet opening, with inscription for appropriate service using color coded letters and background. Metal plates shall have letters embossed on bakedon enamel background. Color coding for identification plates is as follows:

1. Oxygen: White letters on green background.
2. Medical Air: Black letters on yellow background.

2.7 ALARMS

A. Provide all low voltage control wiring, including wiring from alarm relay interface control cabinet to BAS, required for complete, proper functioning system, in conformance with Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES. Run wiring in conduit, in conformance with Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS.

B. Master Alarm Functions: Provide the following individual alarms at the master alarm panel.

1. Oxygen Alarms:

a. Liquid oxygen low level alarm: Functions when stored liquid oxygen reaches a predetermined minimum level.

b. Reserve switchover alarm: Functions when, or just before, reserve oxygen supply goes in operation.

c. Reserve low supply alarm: Functions when contents of cylinder reserve oxygen supply are reduced to one day's average supply; switch and contacts at the bulk tank control panel.

d. Reserve low pressure alarm: Functions when the gas pressure available in the liquid reserve oxygen supply is reduced below the pressure required to function properly.

e. Low pressure alarm: Functions when system pressure downstream of the main shutoff valve drops below 275 kPa (40 psig), ±14 kPa (±2 psig); operated by pressure switch or transmitters.

f. High pressure alarm: functions when system pressure downstream of main shutoff valve increases above 413 kPa (60 psig), ±14 kPa (±2 psig) set points; operated by pressure switches or transmitters.

g. Cylinder reserve pressure low: Functions when the content of a cylinder reserve header is reduced below one day’s average supply.

C. Alarm Functions:

1. Oxygen and medical air alarms: Pressure alarms: Functions when pressure in branch drops below 275 kPa (40 psig), \'b1 14 kPa (\'b1 2 psig) or increases above 414 kPa (60 psig), \'b1 14 kPa (\'b1 2 psig) set points; operated by pressure switches or transmitters.

D. Alarm Panels:

1. General: Modular design, easily serviced and maintained; alarms operate on alternating current (AC) low voltage control circuit; provide required number of transformers for efficient functioning of complete system. Alarm panels shall be integral units, reporting oxygen, medical air, and vacuum services, as required.
2. Box: Flush mounted, sectional or one piece, corrosion resistant. Size box to accommodate required number of service functions for each location, and for one audible signal in each box. Anchor box securely. Provide spare capacity to accommodate 50 percent of the number of provided alarm points.
3. Cover plate: Designed to accommodate required number of signals, visual and audible, for each location, and containing adequate operating instructions within the operator's view. Bezel shall be extruded aluminum, chromium plated metal, or plastic. Secure to the box with chromium plated or stainless steel countersunk screws.
4. Service indicator lights: Red translucent plastic or LED with proper service identification inscribed thereon. Number of lights and service instruction shall be as required for each location. Provide each panel with a green test button of the same material, inscribed with "PUSH TO TEST" or similar message.
5. Audible signal: Provide one in each alarm panel and connect electrically with all service indicator light functions.
6. Controls:
   a. Visual signal: When the condition occurs which any individual service indicator light is to report, button for particular service shall give a lighted visual signal which cannot be canceled until such condition is corrected.

b. Audible signal: Alarm shall give an audible signal upon circuit energization of any visual signal. Audible signal shall be continuous until silenced by pushing a button. This shall cancel and reset audible only, and not affect the visual signal. After silencing, subsequent alarms shall reactivate the audible alarm.

c. Signal tester: Test button or separate normal light shall be continuously lighted to indicate electrical circuit serving each individual alarm is energized. Pushing test button shall temporarily activate all visual signals and sound audible signal, thereby providing desired indications of status of system.

E. Alarm Relay Interface Control Cabinet: Design cabinet to transfer the closed circuit alarm signals through relays to a set of terminals for monitoring signals at the BAS without interrupting the closed circuit system. Constructed of 1.9 mm (14 gage) steel, conforming with NEMA ICS 6, Type 1, enclosures. Provide both normally open and normally closed contacts for output signals, with number of circuits required for full alarm capability at the BAS. Refer to Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC for compatibility.

F. Alarm Network Communication: Network communications board shall be installed in local alarm and connected to the contractor supplied network. Local alarm modules shall send information to the master alarm and the data can be downloaded thru the computer connected to the contractor supplied network. Master alarm displays the message, sounds its alarm and saves the information in an event log. This event log shall be downloaded to a computer file for tracking data and troubleshooting.

2.8 PRESSURE SWITCHES

A. General purpose, contact or mercury type, allowing both high and low pressure set points, with contact type provided with a protective dust cover; adjustable range; switches activate when indicated by alarm requirements. Use one orifice nipple (or DISS demand check valve) for each sensor or pressure switch.

PART 3 - EXECUTION

3.1 INSTALLATION

A. In accordance with NFPA 99.

B. Open ends of tube shall be capped or plugged at all times or otherwise sealed until final assembly to prevent infiltration of any foreign matter.

C. Cut piping square and accurately with a tube cutter (sawing is prohibited) to measurements determined at place of installation. Ream tube to remove burrs, being careful not to expand tube, and so no chips of copper remain in the tube. Work into place without springing or forcing. Bottom tube in socket so there are no gaps between tube and fitting. Exercise care in handling equipment and tools used in cutting or reaming of tube to prevent oil or grease being introduced into tubing. Where contamination has occurred, material is no longer suitable for oxygen service.

D. Spacing of hangers: NFPA 99.

E. Rigidly support valves and other equipment to prevent strain on tube or joints.

F. While being brazed, joints shall be continuously purged with oil free nitrogen. The flow of purged gas shall be maintained until joint is cool to touch.

G. Do not bend tubing. Use fittings.

H. Support ceiling column assembly from heavy sub-mounting castings furnished with the unit as part of roughingin. Anchor with 15 mm (1/2inch) diameter bolts attached to angle iron frame supported from structural ceiling, unless otherwise indicated.

I. Provide two 25 mm (1 inch) minimum conduits from ceiling column assembly to adjacent corridor, one for mass spectrometer tubing and wiring and one for monitor wiring, for connection to signal cabling network.

J. Install pressure switches, transmitter and gauges to be easily accessed, and provide access panel where installed above plaster ceiling. Install pressure switch and sensors with orifice nipple between the pipe line and switches/sensors.

K. Apply pipe labeling during installation process and not after installation is completed. Size of legend letters shall be in accordance with ASME A13.1.

L. Pipe compressor intake to a source of clean ambient air as indicated in NFPA 99.

M. After initial leakage testing is completed, allow piping to remain pressurized with testing gas until testing agency performs final tests.

N. Penetrations:

1. Fire Stopping: Where pipes pass through fire partitions, fire walls, smoked partitions, or floors, install a fire stop that provides an effective barrier against the spread of fire, smoke and gases as specified in Section 07 84 00, FIRESTOPPING, with intumescent materials only. Completely fill and seal clearances between raceways and openings with the fire stopping material.
2. Waterproofing: At floor penetrations, completely seal clearances around the pipe and make watertight with sealant as specified in Section 07 92 00, JOINT SEALANTS. Bio-based materials shall be utilized when possible.

O. Provide 40 mm (1-1/2 inch) diameter line pressure gage downstream of zone valve in cabinets.

P. Provide zone valves in cabinets where indicated and outside each Operating Room and a minimum one zone valve assembly for each 18 outlet set.

3.2 STARTUP AND TESTING

A. Initial Tests: Blow down and high and low pressure leakage tests as required by NFPA 99 with documentation.

B. Laboratory and/or healthcare testing agency shall perform the following:

1. Perform and document all cross connection tests, labeling verification, supply system operation, and valve and alarm operation tests as required by, and in accordance with NFPA 99 and the procedures set forth in pre-qualification documentation.

2. Verify that the systems, as installed, meet or exceed the requirements of NFPA 99, this specification, and that the systems operate as required.
3. Piping purge test: For each positive pressure gas system, verify cleanliness of piping system. Filter a minimum of 1000 liters (35 cubic feet) of gas through a clean white 0.45 micron filter at a minimum velocity of 100 liters per minute (3.5 SCFM). Filter shall show no discoloration, and shall accrue no more than 0.1 mg (0.0000035 ounces) of matter. Test each zone at the outlet most remote from the source. Perform test with the use of an inert gas as described in CGA P9.
4. Piping purity test: For each positive pressure system, verify purity of piping system. Test each zone at the most remote outlet for dew point, carbon monoxide, total hydrocarbons (as methane), and halogenated hydrocarbons, and compare with source gas. The two tests shall in no case exceed variation as specified in paragraph, “Maximum Allowable Variation”. Perform test with the use of an inert gas as described in CGA P9.
5. Outlet and inlet flow test:
   a. Test all outlets for flow. Perform test with the use of an inert gas as described in CGA P9.
   b. Oxygen and medical air outlets shall deliver 100 Lpm (3.5 SCFM) with a pressure drop of no more than 34 kPa (5 psig), and static pressure of 345 kPa (50 psig).
6. Source Contamination Test: Analyze each pressure gas source for concentration of contaminants, by volume. Take samples for air system test at the intake and at a point immediately downstream of the final filter outlet. The compared tests shall in no case exceed variation as specified in paragraph “Maximum Allowable Variation”. Allowable concentrations are below the following:
   a. Dew point, air: 4 degrees C (40 degrees\~F) pressure dew point at 690 kPa (100 psig)
   b. Carbon monoxide, air: 10 mg/L (ppm)
   c. Carbon dioxide, air: 500 mg/L (ppm)
   d. Gaseous hydrocarbons as methane, air: 25 mg/L (ppm)

e. Halogenated hydrocarbons, air: 2 mg/L (ppm)

7. Analysis Test:
   a. Analyze each pressure gas source and outlet for concentration of gas, by volume.
   b. Make analysis with instruments designed to measure the specific gas dispensed.
   c. Allowable concentrations are within the following:
      1) Oxygen: >=97% plus oxygen
      2) Medical air: 19.5% to 23.5% oxygen
8. Maximum Allowable Variation: Between comparative test results required are as follows:
   a. Dew point: 2 degrees C (35 degrees F)
   b. Carbon monoxide: 2 mg/L (ppm)
   c. Total hydrocarbons as methane: 1 mg/L (ppm)
   d. Halogenated hydrocarbons: 2 mg/L (ppm)

C. The CxA will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the COR and CxA. Contractor shall provide a minimum of 10 working days prior to startup and testing.

3.3 CONNECTION TO EXISTING LABORATORY GAS SYSTEM

A. Contactor shall test the existing system for hydrocarbons, dew point, etc. per NFPA 99. If problems are present, the COR would notify the facility of the results. The facility would then make the necessary repairs and/or maintenance prior to connecting to new system.

B. Install shut-off valve at the connection of new line to existing line.

C. Time for shutdown of the existing laboratory and healthcare system shall be coordinated at least 10 work days prior to shutdown with the COR and VA Medical Center.

D. Shut off all oxygen zone valves and gas riser valves if the section to be connected cannot be totally isolated from the remainder of the system.

E. Prior to any work being done, check the new pipeline for particulate or other forms of contamination per NFPA 99.

F. Ensure that the correct type of pipe tubing and fittings are being used.

G. Make a spot check of the existing pipelines in the facility to determine the level of cleanness present.
H. Reduce the pressure to zero and make the tie-in as quickly as possible. A nitrogen purge is not required since this would require another opening in the pipe.
I. After the tie-in is made and allowed to cool, slowly bleed the source gas back into the pipeline. Test the work area for leaks with soapy water and repair any leaks.
J. After all leaks, if any, are repaired and the line is fully recharged, perform blow down and testing. Open the zone that is closest to the main to the system, access the closest outlet to the work, and blow the main through the outlet. After the outlet blows clear into a white cloth, make an additional check at a zone most distant from the work. Perform all required NFPA 99 tests after connection.

3.4 BCOMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.
B. Components provided under this section of the specification will be tested as part of a larger system.

3.5 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer' s technical representative for four hours to instruct VA Personnel in operation and maintenance of units.
B. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

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SECTION 23 05 11
COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 DESCRIPTION

A. The requirements of this Section apply to all sections of Division 23.

1.2 DEFINITIONS

A. Exposed: Piping, ductwork, and equipment exposed to view in finished rooms.

B. Exterior: Piping, ductwork, and equipment exposed to weather be it temperature, humidity, precipitation, wind, or solar radiation.

C. Option or optional: Contractor's choice of an alternate material or method.

D. COR: Contracting Officer’s Representative.

1.3 ABBREVIATIONS/ACRONYMS

A. AC: Air Conditioning

B. ACU: Air Conditioning Unit

C. AI: Analog Input

D. AISI: American Iron and Steel Institute

E. AO: Analog Output

F. ASJ: All Service Jacket

G. AWG: American Wire Gauge

H. BACnet: Building Automation and Control Networking Protocol

I. bhp: Brake Horsepower

J. Btu: British Thermal Unit

K. Btu/h: British Thermal Unit Per Hour

L. C: Celsius

M. CFM: Cubic Foot Per Minute

N. CHR: Chilled Water Return

O. CHS: Chilled Water Supply

P. COR: Contracting Officer’s Representative

Q. CRS: Corrosion Resistant Steel

R. CW: Cold Water

S. CWP: Cold Working Pressure

T. dB: Decibels

U. dB(A): Decibels (A weighted)
V. DDC: Direct Digital Control
W. DI: Digital Input
X. DO: Digital Output
Y. DWV: Drainage, Waste and Vent
Z. F: Fahrenheit
AA. FAR: Federal Acquisition Regulations
BB. gpm: Gallons Per Minute
CC. HOA: Hands-Off-Automatic
DD. hp: Horsepower
EE. HW: Hot Water
FF. HWH: Hot Water Heating Supply
GG. HWHR: Hot Water Heating Return
HH. Hz: Hertz
II. ID: Inside Diameter
JJ. IPS: Iron Pipe Size
KK. kg: Kilogram
LL. lb: Pound
MM. L/s: Liters Per Second
NN. MAX: Maximum
OO. m: Meter
PP. MIN: Minimum
QQ. mm: Millimeter
RR. NC: Normally Closed
SS. NO: Normally Open
TT. NPT: National Pipe Thread
UU. NPS: Nominal Pipe Size
VV. OD: Outside Diameter
WW. PID: Proportional-Integral-Differential
XX. PLC: Programmable Logic Controllers
YY. ppm: Parts Per Million
ZZ. PSIA: Pounds Per Square Inch Absolute
AAA. psig: Pounds Per Square Inch Gauge
BBB. RPM: Revolutions Per Minute
CCC. TAB: Testing, Adjusting, and Balancing

DDD. TEFC: Totally Enclosed Fan-Cooled

EEE. THHN: Thermoplastic High-Heat Resistant Nylon Coated Wire

FFF. THWN: Thermoplastic Heat & Water-Resistant Nylon Coated Wire

GGG. T/P: Temperature and Pressure

HHH. V: Volt

III. VA: Veterans Administration

JJJ. VA CFM: VA Construction & Facilities Management

KKK. VA CFM CSS: VA Construction & Facilities Management, Consulting Support Service

LLL. VAMC: Veterans Administration Medical Center

1.4 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

D. Section 03 30 00, CAST-IN-PLACE CONCRETE.

E. Section 07 84 00, JOINT FIRESTOPPING.

F. Section 07 84 13, PENETRATION FIRESTOPPING.

G. Section 09 91 14, EXTERIOR PAINTING.

H. Section 09 91 24, INTERIOR PAINTING.

I. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

J. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.

K. Section 23 07 11, HVAC AND BOILER PLANT INSULATION.

L. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

M. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

N. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

O. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES.

1.5 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Where conflicts occur these specifications and the VHA standard will govern.

B. Air Movement and Control Association (AMCA):

1. 410-1996 Recommended Safety Practices for Users and Installers of Industrial and Commercial Fans

C. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):
   1. 15-2019 Safety Standard for Refrigeration Systems
   2. 62.1-2019 Ventilation for Acceptable Indoor Air Quality
   3. 90.1-2019 Energy Standard for Buildings Except Low-Rise Residential Buildings
   4. 170-2017 Ventilation of Health Care Facilities

D. American Society of Mechanical Engineers (ASME):
   1. B31.1-2018 Power Piping
   2. B31.9-2014 Building Services Piping
   3. BVPC Boiler and Pressure Vessel Code
   4. Section IX-2019 Welding, Brazing, and Fusing Qualifications

E. American Society for Testing and Materials (ASTM):
   1. A36/A36M-2014 Standard Specification for Carbon Structural Steel
   2. A575-1996(R2018) Standard Specification for Steel Bars, Carbon, Merchant Quality, M-Grades

F. Association for Rubber Products Manufacturers (ARPM):
   1. IP-20-2015 Specifications for Drives Using Classical V-Belts and Sheaves
   2. IP-21-2016 Specifications for Drives Using Double-V (Hexagonal) Belts
   3. IP-24-2016 Specifications for Drives Using Synchronous Belts
   4. IP-27-2015 Specifications for Drives Using Curvilinear Toothed Synchronous Belts

G. Manufacturers Standardization Society (MSS) of the Valve and Fittings Industry, Inc.:
   1. SP-58-2018 Pipe Hangers and Supports-Materials, Design, Manufacture, Selection, Application, and Installation
   2. SP-127-2014a Bracing for Piping Systems: Seismic-Wind-Dynamic Design, Selection, and Application

H. Military Specifications (MIL):
   1. MIL-P-21035B-2013 Paint High Zinc Dust Content, Galvanizing Repair (Metric)

I. National Fire Protection Association (NFPA):
   1. 70-2021 National Electrical Code (NEC)
   2. 101-2021 Life Safety Code

J. Department of Veterans Affairs (VA):
   1. PG-18-10-2016 Physical Security and Resiliency Design Manual

1.6 SUBMITTALS

A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 23 05 11, COMMON WORK RESULTS FOR HVAC", with applicable paragraph identification.

C. Contractor shall make all necessary field measurements and investigations to assure that the equipment and assemblies will meet contract requirements, and all equipment that requires regular maintenance, calibration, etc. are accessible from the floor or permanent work platform. It is the Contractor' s responsibility to ensure all submittals meet the VA specifications and requirements and it is assumed by the VA that all submittals do meet the VA specifications unless the Contractor has requested a variance in writing and approved by COR prior to the submittal. If at any time during the project it is found that any item does not meet the VA specifications and there was no variance approval the Contractor shall correct at no additional cost or time to the Government even if a submittal was approved.

D. If equipment is submitted which differs in arrangement from that shown, provide documentation proving equivalent performance, design standards and drawings that show the rearrangement of all associated systems. Additionally, any impacts on ancillary equipment or services such as foundations, piping, and electrical shall be the Contractor's responsibility to design, supply, and install at no additional cost or time to the Government. VA approval will be given only if all features of the equipment and associated systems, including accessibility, are equivalent to that required by the contract.

E. Prior to submitting shop drawings for approval, Contractor shall certify in writing that manufacturers of all major items of equipment have each reviewed contract documents, and have jointly coordinated and properly integrated their equipment and controls to provide a complete and efficient installation.

F. Submittals and shop drawings for interdependent items, containing applicable descriptive information, shall be furnished together. Coordinate and properly integrate materials and equipment to provide a completely compatible and efficient installation.

G. Coordination/Shop Drawings:

1. Submit complete consolidated and coordinated shop drawings for all new systems, and for existing systems that are in the same areas.
2. The coordination/shop drawings shall include plan views, elevations and sections of all systems and shall be on a scale of not less than 1:32 (3/8-inch equal to one foot). Clearly identify and dimension the proposed locations of the principal items of equipment. The drawings shall clearly show locations and adequate clearance for all equipment, piping, valves, control panels and other items. Show the access means for all items requiring access for operations and maintenance. Provide detailed coordination/shop drawings of all piping and duct systems. The drawings should include all lockout/tagout points for all energy/hazard sources for each piece of equipment. Coordinate lockout/tagout procedures and practices with local VA requirements.
3. Do not install equipment foundations, equipment or piping until coordination/shop drawings have been approved.
4. In addition, for HVAC systems, provide details of the following:
   a. Mechanical equipment rooms.
   b. Interstitial space.
   c. Hangers, inserts, supports, and bracing.
   d. Pipe sleeves.
   e. Duct or equipment penetrations of floors, walls, ceilings, or roofs.

H. Manufacturer's Literature and Data: Include full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity. Submit under the pertinent section rather than under this section.
   1. Submit belt drive with the driven equipment. Submit selection data for specific drives when requested by the COR.
   2. Submit electric motor data and variable speed drive data with the driven equipment.
   3. Equipment and materials identification.
   4. Fire-stopping materials.
   5. Hangers, inserts, supports and bracing. Provide complete stress analysis for variable spring and constant support hangers.
   6. Wall, floor, and ceiling plates.

I. Rigging Plan: Provide documentation of the capacity and weight of the rigging and equipment intended to be used. The plan shall include the path of travel of the load, the staging area and intended access, and qualifications of the operator and signal person.

J. HVAC Maintenance Data and Operating Instructions:
   1. Maintenance and operating manuals in accordance with Section 01 00 00, GENERAL REQUIREMENTS, Article, INSTRUCTIONS, for systems and equipment.
   2. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replacement parts, and troubleshooting guide:
      a. Include complete list indicating all components of the systems.
      b. Include complete diagrams of the internal wiring for each item of equipment.
      c. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.
   3. Provide a listing of recommended replacement parts for keeping in stock supply, including sources of supply, for equipment. Include in the listing belts for equipment: Belt manufacturer, model number, size and style, and distinguished whether of multiple belt sets.

K. Provide copies of approved HVAC equipment submittals to the TAB Subcontractor.

L. Completed System Readiness Checklist provided by the Commissioning Agent and completed by the Contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

M. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

1.7 QUALITY ASSURANCE

A. Mechanical, electrical and associated systems shall be safe, reliable, efficient, durable, easily and safely operable and maintainable, easily and safely accessible, and in compliance with applicable codes as specified. The systems shall be comprised of high quality institutional-class and industrial-class products of manufacturers that are experienced specialists in the required product lines. All construction firms and personnel shall be experienced and qualified specialists in industrial and institutional HVAC.

B. Flow Rate Tolerance for HVAC Equipment: Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.

C. Equipment Vibration Tolerance:

1. Refer to Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT. Equipment shall be factory-balanced to this tolerance and re-balanced on site, as necessary.
2. After HVAC air balance work is completed and permanent drive sheaves are in place, perform field mechanical balancing and adjustments required to meet the specified vibration tolerance.

D. Products Criteria:

1. Standard Products: Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products for at least 3 years (or longer as specified elsewhere). The design, model and size of each item shall have been in satisfactory and efficient operation on at least three installations for approximately three years. However, digital electronics devices, software and systems such as controls, instruments, computer work station, shall be the current generation of technology and basic design that has a proven satisfactory service record of at least three years. See other specification sections for any exceptions and/or additional requirements.
2. Refer to all other sections for quality assurance requirements for systems and equipment specified therein.
3. All items furnished shall be free from defects that would adversely affect the performance, maintainability and appearance of individual components and overall assembly.
4. The products and execution of work specified in Division 23 shall conform to the referenced codes and standards as required by the specifications. Local codes and amendments shall be enforced, along with requirements of local utility companies. The most stringent requirements of these specifications, local codes, or utility company requirements shall always apply. Any conflicts shall be brought to the attention of the COR.
5. Multiple Units: When two or more units of materials or equipment of the same type or class are required, these units shall be of the same manufacturer and model number, or if different models are required they shall be of the same manufacturer and identical to the greatest extent possible (i.e., same model series).
6. Assembled Units: Performance and warranty of all components that make up an assembled unit shall be the responsibility of the manufacturer of the completed assembly.

7. Nameplates: Nameplate bearing manufacturer's name or identifiable trademark shall be securely affixed in a conspicuous place on equipment, or name or trademark cast integrally with equipment, stamped or otherwise permanently marked on each item of equipment.
8. Use of asbestos products or equipment or materials containing asbestos is prohibited.

E. HVAC Equipment Service Providers: Service providers shall be authorized and trained by the manufacturers of the equipment supplied. These providers shall be capable of responding onsite and provide acceptable service to restore equipment operations within 4 hours of receipt of notification by phone, e-mail or fax in event of an emergency, such as the shutdown of equipment; or within 24 hours in a non-emergency. Submit names, mail and e-mail addresses and phone numbers of service personnel and companies providing service under these conditions for (as applicable to the project): fans, air handling units, control systems, computer workstations, and programming.

F. HVAC Mechanical Systems Welding: Before any welding is performed, Contractor shall submit a certificate certifying that welders comply with the following requirements:
1. Qualify welding processes and operators for piping according to ASME BPVC Section IX. Provide proof of current certification.
2. Comply with provisions of ASME B31 series "Code for Pressure Piping".
3. Certify that each welder and welding operator has passed American Welding Society (AWS) qualification tests for the welding processes involved, and that certification is current.
4. All welds shall be stamped according to the provisions of the AWS or ASME as required herein and by the associated code.

G. Manufacturer's Recommendations: Where installation procedures or any part thereof are required to be in accordance with the recommendations of the manufacturer of the material being installed, printed copies of these recommendations shall be furnished to the COR with submittals. Installation of the item will not be allowed to proceed until the recommendations are received. Failure to furnish these recommendations can be cause for rejection of the material and removal by the Contractor and no additional cost or time to the Government.

H. Execution (Installation, Construction) Quality:

1. Apply and install all items in accordance with manufacturer's written instructions. Refer conflicts between the manufacturer's instructions and the contract documents to the COR for resolution. Provide written hard copies and computer files on CD or DVD of manufacturer' s installation instructions to the COR with submittals prior to commencing installation of any item. Installation of the item will not be allowed to proceed until the recommendations are received and approved by the VA. Failure to furnish these recommendations is a cause for rejection of the material.
2. All items that require access, such as for operating, cleaning, servicing, maintenance, and calibration, shall be easily and safely accessible by persons standing at floor level, or standing on permanent platforms, without the use of portable ladders. Examples of these items include, but are not limited to, all types of valves, filters and strainers, transmitters, control devices. Prior to commencing installation work, refer conflicts between this requirement and contract documents to the COR for resolution. Failure of the Contractor to resolve, or point out any issues will result in the Contractor correcting at no additional cost or time to the Government.
3. Complete coordination/shop drawings shall be required in accordance with Article, SUBMITTALS. Construction work shall not start on any system until the coordination/shop drawings have been approved by VA.

4. Workmanship/craftsmanship will be of the highest quality and standards. The VA reserves the right to reject any work based on poor quality of workmanship this work shall be removed and done again at no additional cost or time to the Government.

I. Upon request by Government, provide lists of previous installations for selected items of equipment. Include contact persons who will serve as references, with current telephone numbers and e-mail addresses.

J. Guarantee: Warranty of Construction, FAR Clause 52.246-21.

1.8 DELIVERY, STORAGE AND HANDLING

A. Protection of Equipment:

1. Equipment and material placed on the job site shall remain in the custody of the Contractor until phased acceptance, whether or not the Government has reimbursed the Contractor for the equipment and material. The Contractor is solely responsible for the protection of such equipment and material against any damage or theft.
2. Large equipment such as fans and air handling units if shipped on open trailer trucks shall be covered with shrink on plastics or water proof tarpaulins that provide protection from exposure to rain, road salts and other transit hazards. Protection shall be kept in place until equipment is moved into a building or installed as designed.
3. Repair damaged equipment in first class, new operating condition and appearance; or, replace same as determined and directed by the COR. Such repair or replacement shall be at no additional cost or time to the Government.
4. Protect interiors of new equipment and piping systems against entry of foreign matter. Clean both inside and outside before painting or placing equipment in operation.
5. Existing equipment and piping being worked on by the Contractor shall be under the custody and responsibility of the Contractor and shall be protected as required for new work.
6. Protect plastic piping and tanks from ultraviolet light (sunlight).

B. Cleanliness of Piping and Equipment Systems:

1. Exercise care in storage and handling of equipment and piping material to be incorporated in the work. Remove debris arising from cutting, threading and welding of piping.
2. Piping systems shall be flushed, blown or pigged as necessary to deliver clean systems.
3. Clean interior of all tanks prior to delivery for beneficial use by the Government.
4. Contractor shall be fully responsible for all costs, damage, and delay arising from failure to provide clean systems.

1.9 AS-BUILT DOCUMENTATION

A. Submit manufacturer's literature and data updated to include submittal review comments and any equipment substitutions.

B. Submit operation and maintenance data updated to include submittal review comments, substitutions and construction revisions shall be in electronic version on CD or DVD inserted into a three ring binder. All aspects of system operation and maintenance procedures, including piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices such as damper and door closure interlocks shall be included. A List of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.

C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the ' third party testing company' requirement.

D. As-built drawings:

1. As-built drawings are to be provided, and a copy of them on Auto-Cad version 2018 or newer provided on compact disk or DVD.

E. Certification documentation shall be provided to COR 21 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and provide documentation/certification that all results of tests were within limits specified. Test results shall contain written sequence of test procedure with written test results annotated at each step along with the expected outcome or setpoint. The results shall include all readings, including but not limited to data on device (make, model and performance characteristics), normal pressures, switch ranges, trip points, amp readings, and calibration data to include equipment serial numbers or individual identifications, etc.

F. The as-built drawings shall indicate the location and type of all lockout/tagout points for all energy sources for all equipment and pumps to include breaker location and numbers, valve tag numbers, etc. Coordinate lockout/tagout procedures and practices with local VA requirements.

1.10 BJOB CONDITIONS - WORK IN EXISTING BUILDINGS

A. Building Operation: Refer to Division 1 for building operation information for the facility.

B. Maintenance of Service: Refer to Division 1 for requirements regarding work hours and interruption of programs/service at the facility.

C. Building Working Environment: Maintain the architectural and structural integrity of the building and the working environment at all times. Maintain the interior of building at 18 degrees C (65 degrees F) minimum. Limit the opening of doors, windows or other access openings to brief periods as necessary for rigging purposes. Storm water or ground water leakage is prohibited. Provide daily clean-up of construction and demolition debris on all floor surfaces and on all equipment being operated by VA. Maintain all egress routes and safety systems/devices.

D. Acceptance of Work for Government Operation: As new equipment, systems and facilities are made available for operation and these items are deemed of beneficial use to the Government, inspections will be made and tests will be performed. Based on the inspections, a list of contract deficiencies will be issued to the Contractor. After correction of deficiencies as necessary for beneficial use, the Contracting Officer will process necessary acceptance and the equipment will then be under the control and operation of Government personnel.

E. Heat: Furnish temporary heat necessary to prevent injury to work and materials through dampness and cold. Use of open salamanders or any temporary heating devices which may be fire hazards or may smoke and damage finished work, will not be permitted. Maintain minimum temperatures as specified for various materials.

F. Data Room Heating/Cooling/Humidification/Dehumidification: Furnish temporary heating, cooling, humidification, & dehumidification provisions to maintain required conditions in all operational data room spaces.
   1. Maintain the following conditions:
      a. Temperature: 72-81˚F
      b. Humidity: 30-60% RH, non-condensing
   2. These provisions shall be made for the following spaces:
      a. Modified TR spaces remaining in operation throughout construction.

PART 2 - PRODUCTS

2.1 FACTORY-ASSEMBLED PRODUCTS

A. Provide maximum standardization of components to reduce spare part requirements.

B. Manufacturers of equipment assemblies that include components made by others shall assume complete responsibility for final assembled unit.
   1. All components of an assembled unit need not be products of same manufacturer.
   2. Constituent parts that are alike shall be products of a single manufacturer.

3. Components shall be compatible with each other and with the total assembly for intended service.
4. Contractor shall guarantee performance of assemblies of components, and shall repair or replace elements of the assemblies as required to deliver specified performance of the complete assembly.

C. Components of equipment shall bear manufacturer's name and trademark, model number, serial number and performance data on a name plate securely affixed in a conspicuous place, or cast integral with, stamped or otherwise permanently marked upon the components of the equipment.

D. Major items of equipment, which serve the same function, must be the same make and model.

2.2 COMPATIBILITY OF RELATED EQUIPMENT

Equipment and materials installed shall be compatible in all respects with other items being furnished and with existing items so that the result will be a complete and fully operational plant that conforms to contract requirements.

2.3 V-BELT DRIVES

A. Type: ARPM standard V-belts with proper motor pulley and driven sheave. Belts shall be constructed of reinforced cord and rubber.

B. Dimensions, rating and selection standards: ARPM IP-20 and ARPM IP-21.

C. Minimum Horsepower Rating: Motor horsepower plus recommended ARPM service factor (not less than 20 percent) in addition to the ARPM allowances for pitch diameter, center distance, and arc of contact.

D. Maximum Speed: 25 m/s (5000 feet per minute).

E. Adjustment Provisions: For alignment and ARPM standard allowances for installation and take-up.

F. Drives may utilize a single V-Belt (any cross section) when it is the manufacturer's standard.

G. Multiple Belts: Matched to ARPM specified limits by measurement on a belt measuring fixture. Seal matched sets together to prevent mixing or partial loss of sets. Replacement, when necessary, shall be an entire set of new matched belts.

H. Sheaves and Pulleys:
   1. Material: Pressed steel, or close-grained cast iron.
   2. Bore: Fixed or bushing type for securing to shaft with keys.
   3. Balanced: Statically and dynamically.
   4. Groove spacing for driving and driven pulleys shall be the same.

I. Drive Types, Based on ARI 435:
   1. Provide adjustable-pitch or fixed-pitch drive as follows:
      a. Fan speeds up to 1800 RPM: 7.5 kW (10 horsepower) and smaller.
      b. Fan speeds over 1800 RPM: 2.2 kW (3 horsepower) and smaller.
   2. Provide fixed-pitch drives for drives larger than those listed above.
   3. The final fan speeds required to just meet the system CFM and pressure requirements, without throttling the design air flow branch, shall be determined by adjustment of a temporary adjustable-pitch motor sheave or by fan law calculation if a fixed-pitch drive is used initially.

J. Final Drive Set: If adjustment is required beyond the capabilities of the factory drive set, the final drive set shall be provided as part of this contract at no additional cost or time to the Government.

2.4 SYNCHRONOUS BELT DRIVES

A. Type: ARPM synchronous belts with proper motor pulley and driven sheave. Belts shall be constructed of reinforced cord and rubber.

B. Dimensions, rating and selection standards: ARPM IP-24 and ARPM IP-27.

C. Minimum Horsepower Rating: Motor horsepower plus recommended ARPM service factor (not less than 20 percent) in addition to the ARPM allowances for pitch diameter, center distance, and arc of contact.

D. Maximum Speed: 25 m/s (5000 feet per minute).

E. Adjustment Provisions: For alignment and ARPM standard allowances for installation and take-up.

F. Drives may utilize a single belt of manufacturer’s standard width for the application.

G. Multiple Belts: Matched to ARPM specified limits by measurement on a belt measuring fixture. Seal matched sets together to prevent mixing or partial loss of sets. Replacement, when necessary, shall be an entire set of new matched belts.

H. Sheaves and Pulleys:
   1. Material: Pressed steel, or close-grained cast iron.
   2. Bore: Fixed or bushing type for securing to shaft with keys.
   3. Balanced: Statically and dynamically.

I. Final Drive Set: The final fan speeds required to just meet the system CFM and pressure requirements, without throttling the design air flow branch, shall be determined by fan law calculation. If adjustment is required beyond the capabilities of the factory drive set, the final drive set shall be provided as part of this contract at no additional cost or time to the Government.

2.5 DRIVE GUARDS

A. For machinery and equipment, provide guards as shown in AMCA 410 for belts, chains, couplings, pulley, sheaves, shafts, gears and other moving parts regardless of height above the floor to prevent damage to equipment and injury to personnel. Drive guards may be excluded where motors and drives are inside factory fabricated air handling unit casings.

B. Pump shafts and couplings shall be fully guarded by a sheet steel guard, covering coupling and shaft but not bearings. Material shall be minimum 16-gage sheet steel; ends shall be braked and drilled and attached to pump base with minimum of four 6 mm (1/4-inch) bolts. Reinforce guard as necessary to prevent side play forcing guard onto couplings.

C. V-belt and sheave assemblies shall be totally enclosed, firmly mounted, non-resonant. Guard shall be an assembly of minimum 22-gage sheet steel and expanded or perforated metal to permit observation of belts. 25 mm (one-inch) diameter hole shall be provided at each shaft centerline to permit speed measurement.

D. Materials: Sheet steel, cast iron, expanded metal or wire mesh rigidly secured so as to be removable without disassembling pipe, duct, or electrical connections to equipment.

E. Access for Speed Measurement: 25 mm (One inch) diameter hole at each shaft center.

2.6 LIFTING ATTACHMENTS

A. Provide equipment with suitable lifting attachments to enable equipment to be lifted in its normal position. Lifting attachments shall withstand any handling conditions that might be encountered, without bending or distortion of shape, such as rapid lowering and braking of load.

2.7 ELECTRIC MOTORS

A. All material and equipment furnished and installation methods shall conform to the requirements of Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT and Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES. Provide all electrical wiring, conduit, and devices necessary for the proper connection, protection and operation of the systems. Provide special energy efficient premium efficiency type motors as scheduled.

2.8 VARIABLE SPEED MOTOR CONTROLLERS

A. Refer to Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS and Section 26 29 11, MOTOR CONTROLLERS for specifications.

B. Coordinate variable speed motor controller communication protocol with Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

C. Variable frequency drives (VFD's) shall be as manufactured by ABB or approved equal.

D. Provide variable speed motor controllers with or without a bypass contactor as indicated in contract drawings.

E. The combination of controller and motor shall be provided by the manufacturer of the driven equipment, such as pumps and fans, and shall be rated for 100 percent output performance. Multiple units of the same class of equipment, i.e. air handlers, fans, pumps, shall be product of a single manufacturer.

F. Motors shall be premium efficiency type and be approved by the motor controller manufacturer. The controller-motor combination shall be guaranteed to provide full motor nameplate horsepower in variable frequency operation. Both driving and driven motor/fan sheaves shall be fixed pitch.

G. Controller shall not add any current or voltage transients to the input ac power distribution system, DDC controls, sensitive medical equipment, etc., nor shall be affected from other devices on the ac power system.

H. Controller shall be provided with the following operating features and accessories:

1. Provide with thermal magnetic breaker or fused switch with external operator and incoming line fuses.
2. Unit shall be rated for minimum 25,000 AIC.
3. Provide AC input line reactors (3% impedance) or filters on incoming power line.
4. Provide output line reactors on line between drive and motor where the distance between the breaker and motor exceeds 50 feet.

2.9 EQUIPMENT AND MATERIALS IDENTIFICATION

A. Use symbols, nomenclature and equipment numbers specified, shown on the contract documents and shown in the maintenance manuals.

B. Refer to Section 09 91 14, EXTERIOR PAINTING or Section 09 91 24, INTERIOR PAINTING for painting requirements.

C. Piping Identification

1. Provide flexible, vinyl film tape pipe markers with pressure sensitive adhesive backing and printed markings.
2. Markers shall indicate system and flow direction.
3. Color codes:
   a. Domestic water: Green with white letters.
   b. Heating water and chilled water and other hydronic systems: Yellow with black letters.
   c. Condensate drain systems: Green with white letters.

D. Equipment Identification

1. Interior (Indoor) Equipment: Engraved nameplates, with letters not less than 5 mm (3/16 inch) high of brass with black-filled letters, or rigid black plastic with white letters specified in Section 09 91 00, PAINTING permanently fastened to the equipment.
   a. Identify unit components such as coils, filters, fans, etc.
   b. Indoor unit nameplates shall identify associated outdoor equipment (where applicable).

2. Exterior (Outdoor) Equipment: Brass nameplates, with engraved black filled letters, not less than 5 mm (3/16 inch) high riveted or bolted to the equipment.
   a. Outdoor unit nameplates shall include information regarding associated indoor unit number, area served, and indoor unit location.
3. Labels for equipment located outside of the space(s) served shall include information regarding area served.

E. Control Items: Label all instrumentation, temperature and humidity sensors, controllers and control dampers. Identify and label each item as they appear on the control diagrams.

F. Valve Tags and Lists:
1. HVAC and Mechanical Rooms: Provide for all valves.
2. Valve tags: Engraved black filled numbers and letters not less than 15 mm (1/2 inch) high for number designation, and not less than 6 mm (1/4 inch) for service designation on 19-gauge 40 mm (1-1/2 inches) round brass disc, attached with brass "S" hook or brass chain.
3. Valve lists: Typed or printed plastic coated card(s), sized 215 mm (8-1/2 inches) by 275 mm (11 inches) showing tag number, valve function and area of control, for each service or system. Punch sheets for a 3-ring notebook.
4. Provide detailed plan for each floor of the building indicating the location and valve number for each valve. Identify location of each valve with a color-coded thumb tack in ceiling.

G. Custom print labels with above ceiling HVAC equipment numbers.

2.10 FIRESTOPPING

A. Refer to Section 07 84 00, FIRESTOPPING, for requirements where piping or ductwork penetrate rated assemblies.

B. Refer to Section 23 07 11, HVAC AND BOILER PLANT INSULATION, for pipe and duct insulation requirements at penetrations of rated assemblies.

2.11 GALVANIZED REPAIR COMPOUND

A. Mil-P-21035B, paint form.

2.12 HVAC PIPE AND EQUIPMENT SUPPORTS AND RESTRAINTS

A. Vibration Isolators: Refer to Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.

B. Supports for Roof Mounted Items:

1. Equipment: Equipment rails shall be galvanized steel, minimum 1.3 mm (18 gauge), with integral baseplate, continuous welded corner seams, factory installed 50 by 100 mm (2 by 4 inches) treated wood nailer, 1.3 mm (18 gauge) galvanized steel counter flashing cap with screws, built-in cant strip, (except for gypsum or tectum deck), minimum height 275 mm (11 inches). For surface insulated roof deck, provide raised cant strip to start at the upper surface of the insulation.
2. Pipe/duct pedestals: Provide a galvanized Unistrut channel welded to U-shaped mounting brackets which are secured to side of rail with galvanized lag bolts.

C. Pipe Supports: Comply with MSS SP-58. Type Numbers specified refer to this standard. For selection and application comply with MSS SP-58. Refer to Section 05 50 00, METAL FABRICATIONS, for miscellaneous metal support materials and prime coat painting requirements.

D. Attachment to Concrete Building Construction:

1. Concrete insert: MSS SP-58, Type 18.
2. Self-drilling expansion shields and machine bolt expansion anchors: Permitted in concrete not less than 100 mm (4 inches) thick when approved by the COR for each job condition.
3. Power-driven fasteners: Permitted in existing concrete or masonry not less than 100 mm (4 inches) thick when approved by the COR for each job condition.

E. Attachment to Steel Building Construction:

1. Welded attachment: MSS SP-58, Type 22.
2. Beam clamps: MSS SP-58, Types 20, 21, 28 or 29. Type 23 C-clamp may be used for individual copper tubing up to 23 mm (7/8 inch) outside diameter.

F. Attachment to existing structure: Support from existing floor/roof frame.

G. Attachment to Wood Construction: Wood screws or lag bolts.

H. Hanger Rods: Hot-rolled steel, ASTM A36/A36M or ASTM A575 for allowable load listed in MSS SP-58. For piping, provide adjustment means for controlling level or slope. Types 13 or 15 turn-buckles shall provide 40 mm (1-1/2 inches) minimum of adjustment and incorporate locknuts. All-thread rods are acceptable.

I. Hangers Supporting Multiple Pipes (Trapeze Hangers): Galvanized, cold formed, lipped steel channel horizontal member, not less than 41 mm by 41 mm (1-5/8 inches by 1-5/8 inches), 2.7 mm (12 gauge), designed to accept special spring held, hardened steel nuts. Trapeze hangers are prohibited for use for steam supply and condensate piping.
   1. Allowable hanger load: Manufacturers rating less 91 kg (200 pounds).
   2. Guide individual pipes on the horizontal member of every other trapeze hanger with 6 mm (1/4 inch) U-bolt fabricated from steel rod. Provide Type 40 insulation shield, secured by two 15 mm (1/2 inch) galvanized steel bands, or preinsulated calcium silicate shield for insulated piping at each hanger.

J. Supports for Piping Systems:
   1. Select hangers sized to encircle insulation on insulated piping. Refer to Section 23 07 11, HVAC AND BOILER PLANT INSULATION for insulation thickness. To protect insulation, provide Type 39 saddles for roller type supports or preinsulated calcium silicate shields. Provide Type 40 insulation shield or preinsulated calcium silicate shield at all other types of supports and hangers including those for preinsulated piping.
   2. Piping Systems except High and Medium Pressure Steam (MSS SP-58):
      a. Standard clevis hanger: Type 1; provide locknut.
      b. Riser clamps: Type 8.
      c. Wall brackets: Types 31, 32 or 33.
      d. Roller supports: Type 41, 43, 44 and 46.
      e. Saddle support: Type 36, 37 or 38.
      f. Turnbuckle: Types 13 or 15. Preinsulate.
      g. U-bolt clamp: Type 24.
      h. Copper Tube:

1) Hangers, clamps and other support material in contact with tubing shall be painted with copper colored epoxy paint, plastic coated or taped with non-adhesive isolation tape to prevent electrolysis.
2) For vertical runs use epoxy painted or plastic-coated riser clamps.
3) For supporting tube to strut: Provide epoxy painted pipe straps for copper tube or plastic inserted vibration isolation clamps.
4) Insulated Lines: Provide pre-insulated calcium silicate shields sized for copper tube.

i. Supports for plastic piping: As recommended by the pipe manufacturer with black rubber tape extending one inch beyond steel support or clamp.

K. Pre-insulated Calcium Silicate Shields:
1. Refer to Section 23 07 11, HVAC and BOILER PLANT INSULATION, for insulation requirements.
2. Provide 360-degree water resistant high density 965 kPa (140 psig) compressive strength calcium silicate shields encased in galvanized metal.
3. Pre-insulated calcium silicate shields to be installed at the point of support during erection.
4. Shield thickness shall match the pipe insulation.
5. The type of shield is selected by the temperature of the pipe, the load it must carry, and the type of support it will be used with.
a. Shields for supporting chilled or cold water shall have insulation that extends a minimum of 25 mm (1 inch) past the sheet metal. Provide for an adequate vapor barrier in chilled lines.

b. The pre-insulated calcium silicate shield shall support the maximum allowable water filled span as indicated in MSS SP-58. To support the load, the shields may have one or more of the following features: structural inserts 4138 kPa (600 psig) compressive strength, an extra bottom metal shield, or formed structural steel (ASTM A36/A36M) wear plates welded to the bottom sheet metal jacket.

6. Shields may be used on steel clevis hanger type supports, roller supports or flat surfaces.

L. Seismic Restraint of Piping and Ductwork: Refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS. Comply with MSS SP-127.

2.13 PIPE PENETRATIONS

A. Install sleeves during construction for other than blocked out floor openings for risers in mechanical bays.

B. To prevent accidental liquid spills from passing to a lower level, provide the following:

1. For sleeves: Extend sleeve 25 mm (one inch) above finished floor and provide sealant for watertight joint.
2. For blocked out floor openings: Provide 40 mm (1-1/2 inch) angle set in silicone adhesive around opening.
3. For drilled penetrations: Provide 40 mm (1-1/2 inch) angle ring or square set in silicone adhesive around penetration.

C. Penetrations are not allowed through beams or ribs, but may be installed in concrete beam flanges. Any deviation from these requirements must receive prior approval of COR.

D. Sheet Metal, Plastic, or Moisture-resistant Fiber Sleeves: Provide for pipe passing through floors, interior walls, and partitions, unless brass or steel pipe sleeves are specifically called for below.

E. Cast Iron or Zinc Coated Pipe Sleeves: Provide for pipe passing through exterior walls below grade. Make space between sleeve and pipe watertight with a modular or link rubber seal. Seal shall be applied at both ends of sleeve.

F. Galvanized Steel or an alternate Black Iron Pipe with asphalt coating Sleeves: Provide for pipe passing through concrete beam flanges, except where brass pipe sleeves are called for. Provide sleeve for pipe passing through floor of mechanical rooms, laundry work rooms, and animal rooms above basement. Except in mechanical rooms, connect sleeve with floor plate.

G. Brass Pipe Sleeves: Provide for pipe passing through quarry tile, terrazzo or ceramic tile floors. Connect sleeve with floor plate.

H. Sleeves are not required for wall hydrants for fire department connections or in drywall construction.

I. Sleeve Clearance: Sleeve through floors, walls, partitions, and beam flanges shall be one inch greater in diameter than external diameter of pipe. Sleeve for pipe with insulation shall be large enough to accommodate the insulation. Interior openings shall be caulked tight with fire stopping material and sealant to prevent the spread of fire, smoke, and gases.

J. Sealant and Adhesives: Shall be as specified in Section 07 92 00, JOINT SEALANTS.

2.14 DUCT PENETRATIONS

A. Provide firestopping for openings through fire and smoke barriers, maintaining minimum required rating of floor, ceiling or wall assembly. See section 07 84 00, FIRESTOPPING.

2.15 ROOF CURBS

A. Provide prefabricated curbs for all roof mounted equipment. Provide equipment curbs with continuously welded seams, built-in cant strips, interior baffle with acoustic insulation, curb bottoms, and hinged curb adapters.

B. Provide roof curbs for piping and ductwork penetrations. Provide curbs with continuously welded seams, built-in cant strips, interior baffle with acoustic insulation, curb bottoms, and hinged curb adapters.

C. Roof curbs shall be configured to match roof slope at equipment location. Equipment shall be installed level.

D. Roof curbs for equipment (such as fans, air handlers, condensing units, and air inlet and outlet hoods, etc.) shall be configured to locate equipment base a minimum of 18 inches above surrounding roof.

2.16 SPECIAL TOOLS AND LUBRICANTS

A. Furnish, and turn over to the COR, tools not readily available commercially, that are required for disassembly or adjustment of equipment and machinery furnished.

B. Grease Guns with Attachments for Applicable Fittings: One for each type of grease required for each motor or other equipment.

C. Refrigerant Tools: Provide system charging/Evacuation equipment, gauges, fittings, and tools required for maintenance of furnished equipment.

D. Tool Containers: Hardwood or metal, permanently identified for intended service and mounted, or located, where directed by the COR.

E. Lubricants: A minimum of 0.95 L (one quart) of oil, and 0.45 kg (one pound) of grease, of equipment manufacturer's recommended grade and type, in unopened containers and properly identified as to use for each different application.

2.17 WALL, FLOOR AND CEILING PLATES

A. Material and Type: Chrome plated brass or chrome plated steel, one piece or split type with concealed hinge, with set screw for fastening to pipe, or sleeve. Use plates that fit tight around pipes, cover openings around pipes and cover the entire pipe sleeve projection.

B. Thickness: Not less than 2.4 mm (3/32-inch) for floor plates. For wall and ceiling plates, not less than 0.64 mm (0.025-inch) for up to 80 mm (3-inch pipe), 0.89 mm (0.035-inch) for larger pipe.

C. Locations: Use where pipe penetrates floors, walls and ceilings in exposed locations, in finished areas only. Provide a watertight joint in spaces where brass or steel pipe sleeves are specified.

2.18 ASBESTOS

A. Materials containing asbestos are not permitted.

PART 3 - EXECUTION

3.1 GENERAL

A. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no additional cost or time to the Government.

3.2 ARRANGEMENT AND INSTALLATION OF EQUIPMENT AND PIPING

A. Location of piping, sleeves, inserts, hangers, and equipment, access provisions shall be coordinated with the work of all trades. The coordination/shop drawings shall be submitted for review. Locate piping, sleeves, inserts, hangers, ductwork and equipment clear of windows, doors, openings, light outlets, and other services and utilities. Equipment coordination/shop drawings shall be prepared to coordinate proper location and personnel access of all facilities. The drawings shall be submitted for review. Follow manufacturer's published recommendations for installation methods not otherwise specified.

B. Operating Personnel Access and Observation Provisions: Select and arrange all equipment and systems to provide clear view and easy access, without use of portable ladders, for maintenance and operation of all devices including, but not limited to: all equipment items, valves, filters, strainers, transmitters, sensors, control devices. All gauges and indicators shall be clearly visible by personnel standing on the floor or on permanent platforms. Do not reduce or change maintenance and operating space and access provisions that are shown on the contract documents.

C. Equipment and Piping Support: Coordinate structural systems necessary for pipe and equipment support with pipe and equipment locations to permit proper installation.

D. Location of pipe sleeves, trenches and chases shall be accurately coordinated with equipment and piping locations.

E. Cutting Holes:

1. Cut holes through concrete and masonry by rotary core drill. Pneumatic hammer, impact electric, and hand or manual hammer type drill will not be allowed, except as permitted by COR where working area space is limited.
2. Locate holes to avoid interference with structural members such as beams or grade beams. Holes shall be laid out in advance and drilling done only after approval by COR. If the Contractor considers it necessary to drill through structural members, this matter shall be referred to COR for approval.
3. Do not penetrate membrane waterproofing.

F. Minor Piping: Generally, small diameter pipe runs from drips and drains, water cooling, and other services are not shown but must be provided.

G. Electrical Interconnection of Instrumentation or Controls: This generally not shown but must be provided. This includes interconnections of sensors, transmitters, transducers, control devices, control and instrumentation panels, instruments and computer workstations. Devices shall be located so they are easily accessible for testing, maintenance, calibration, etc. The COR has the final determination on what is accessible and what is not. Comply with NFPA 70.

H. Protection and Cleaning:
1. Equipment and materials shall be carefully handled, properly stored, and adequately protected to prevent damage before and during installation, in accordance with the manufacturer's recommendations and as approved by the COR. Damaged or defective items in the opinion of the COR, shall be replaced.
2. Protect all finished parts of equipment, such as shafts and bearings where accessible, from rust prior to operation by means of protective grease coating and wrapping. Close pipe openings with caps or plugs during installation. Tightly cover and protect fixtures and equipment against dirt, water chemical, or mechanical injury. At completion of all work thoroughly clean fixtures, exposed materials and equipment.

I. Install gauges, thermometers, valves and other devices with due regard for ease in reading or operating and maintaining said devices. Locate and position thermometers and gauges to be easily read by operator or staff standing on floor or walkway provided. Servicing shall not require dismantling adjacent equipment or pipe work.

J. Work in Existing Building:

1. Perform as specified in Article, OPERATIONS AND STORAGE AREAS, Article, ALTERATIONS, and Article, RESTORATION of the Section 01 00 00, GENERAL REQUIREMENTS for relocation of existing equipment, alterations and restoration of existing building(s).
2. As specified in Section 01 00 00, GENERAL REQUIREMENTS, Article, OPERATIONS AND STORAGE AREAS, make alterations to existing service piping at times that will least interfere with normal operation of the facility.
3. Cut required openings through existing masonry and reinforced concrete using diamond core drills. Use of pneumatic hammer type drills, impact type electric drills, and hand or manual hammer type drills, will be permitted only with approval of the COR. Locate openings that will least effect structural slabs, columns, ribs or beams. Refer to the COR for determination of proper design for openings through structural sections and opening layouts approval, prior to cutting or drilling into structure. After COR's approval, carefully cut opening through construction no larger than absolutely necessary for the required installation.

K. Switchgear/Electrical Equipment Drip Protection: Every effort shall be made to eliminate the installation of pipe above electrical and telephone switchgear & data equipment. If this is not possible, encase pipe in a second pipe with a minimum of joints. Installation of piping, ductwork, leak protection apparatus or other installations foreign to the electrical installation shall be located in the space equal to the width and depth of the equipment and extending from to a height of 1.8 m (6 ft.) above the equipment to ceiling structure, whichever is lower (NFPA 70).

L. Inaccessible Equipment:

1. Where the Government determines that the Contractor has installed equipment not conveniently accessible for operation and maintenance, equipment shall be removed and reinstalled or remedial action performed as directed at no additional cost to the Government.
2. The term "conveniently accessible" is defined as capable of being reached without the use of ladders, or without climbing or crawling under or over obstacles such as motors, fans, pumps, belt guards, transformers, high voltage lines, piping, and ductwork.
   a. Equipment installed in or above ceilings, such as VRF indoor units, VAV boxes, fire dampers, and valves, etc., shall be considered "conveniently accessible" provided that suitable ceiling access is provided by access panels and/or easily removable ceiling tiles, and that access is not blocked by other piping, ductwork, wiring, equipment, structural members, or other building components.

3.3 TEMPORARY PIPING AND EQUIPMENT

A. Continuity of operation of existing facilities will generally require temporary installation or relocation of equipment and piping.

B. The Contractor shall provide all required facilities in accordance with the requirements of phased construction and maintenance of service. All piping and equipment shall be properly supported, sloped to drain, operate without excessive stress, and shall be insulated where injury can occur to personnel by contact with operating facilities. The requirements of Article, ARRANGEMENT AND INSTALLATION OF EQUIPMENT AND PIPING apply.

C. Temporary facilities and piping shall be completely removed and any openings in structures sealed. Provide necessary blind flanges and caps to seal open piping remaining in service.

3.4 RIGGING

A. Design is based on application of available equipment. Openings in building structures are planned to accommodate design scheme.

B. Alternative methods of equipment delivery may be offered by Contractor and will be considered by Government under specified restrictions of phasing and maintenance of service requirements as well as structural integrity of the building.
C. Close all openings in the building when not required for rigging operations to maintain proper environment in the facility for Government operation and maintenance of service.
D. Contractor shall provide all facilities required to deliver specified equipment and place on foundations. Attachments to structures for rigging purposes and support of equipment on structures shall be Contractor's full responsibility. Upon request, the Government will check structure adequacy and advise Contractor of recommended restrictions.
E. Contractor shall check all clearances, weight limitations and shall offer a rigging plan designed by a Registered Professional Engineer. All modifications to structures, including reinforcement thereof, shall be at Contractor's cost, time and responsibility.
F. Follow approved rigging plan.
G. Restore building to original condition upon completion of rigging work.

3.5 PIPE AND EQUIPMENT SUPPORTS

A. Where hanger spacing does not correspond with joist or rib spacing, use structural steel channels designed by a structural engineer, secured directly to joist and rib structure that will correspond to the required hanger spacing, and then suspend the equipment and piping from the channels. Drill or burn holes in structural steel only with the prior approval of the COR.
B. Use of chain pipe supports; wire or strap hangers; wood for blocking, stays and bracing; or, hangers suspended from piping above are prohibited. Replace or thoroughly clean rusty products and paint with zinc primer.
C. Hanger rods shall be used that are straight and vertical. Turnbuckles for vertical adjustments may be omitted where limited space prevents use. Provide a minimum of 15 mm (1/2 inch) clearance between pipe or piping covering and adjacent work.

D. HVAC Horizontal Pipe Support Spacing: Refer to MSS SP-58. Provide additional supports at valves, strainers, in-line pumps and other heavy components. Provide a support within one foot of each elbow.

E. HVAC Vertical Pipe Supports:

1. Up to 150 mm (6-inch pipe), 9 m (30 feet) long, bolt riser clamps to the pipe below couplings, or welded to the pipe and rests supports securely on the building structure.
2. Vertical pipe larger than the foregoing, support on base elbows or tees, or substantial pipe legs extending to the building structure.

F. Overhead Supports:

1. The basic structural system of the building is designed to sustain the loads imposed by equipment and piping to be supported overhead.
2. Provide steel structural members, in addition to those shown, of adequate capability to support the imposed loads, located in accordance with the final approved layout of equipment and piping.
3. Tubing and capillary systems shall be supported in channel troughs.

G. Floor Supports:

1. Provide concrete bases, concrete anchor blocks and pedestals, and structural steel systems for support of equipment and piping. Concrete bases and structural systems shall be anchored and doweled to resist forces under operating and seismic conditions (if applicable) without excessive displacement or structural failure.
2. Bases and supports shall not be located and installed until equipment mounted thereon has been approved. Bases shall be sized to match equipment mounted thereon plus 50 mm (2 inch) excess on all edges. Chiller foundations shall have horizontal dimensions that exceed chiller base frame dimensions by at least 150 mm (6 inches) on all sides. Structural contract documents shall be reviewed for additional requirements. Bases shall be neatly finished and smoothed, shall have chamfered edges at the top, and shall be suitable for painting.

3. All equipment shall be shimmed, leveled, firmly anchored, and grouted with epoxy grout. Anchor bolts shall be placed in sleeves, anchored to the bases. Fill the annular space between sleeves and bolts with a granular material to permit alignment and realignment.
4. For seismic anchoring, refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

3.6 MECHANICAL DEMOLITION

A. Rigging access, other than indicated on the contract documents, shall be provided by the Contractor after approval for structural integrity by the COR. Such access shall be provided without additional cost or time to the Government. Where work is in an operating plant, provide approved protection from dust and debris at all times for the safety of plant personnel and maintenance of plant operation and environment of the plant.

B. In an operating facility, maintain the operation, cleanliness and safety. Government personnel will be carrying on their normal duties of operating, cleaning and maintaining equipment and plant operation. Confine the work to the immediate area concerned; maintain cleanliness and wet down demolished materials to eliminate dust. Debris accumulated in the area to the detriment of plant operation is prohibited. Perform all flame cutting to maintain the fire safety integrity of this plant. Adequate fire extinguishing facilities shall be available at all times. Perform all work in accordance with recognized fire protection standards. Inspection will be made by personnel of the VAMC, and Contractor shall follow all directives of the COR with regard to rigging, safety, fire safety, and maintenance of operations.

C. Unless specified otherwise, all piping, wiring, conduit, and other devices associated with the equipment not re-used in the new work shall be completely removed from Government property per Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT. This includes all concrete pads, pipe, valves, fittings, insulation, and all hangers including the top connection and any fastenings to building structural systems. All openings shall be sealed after removal of equipment, pipes, ducts, and other penetrations in roof, walls, floors, in an approved manner and in accordance with contract documents where specifically covered. Structural integrity of the building system shall be maintained. Reference shall also be made to the contract documents of the other disciplines in the project for additional facilities to be demolished or handled.

D. All indicated valves including gate, globe, ball, butterfly and check, all pressure gauges and thermometers with wells shall remain Government property and shall be removed and delivered to COR and stored as directed. The Contractor shall remove all other material and equipment, devices and demolition debris under these contract documents. Such material shall be removed from Government property expeditiously and shall not be allowed to accumulate.

3.7 CLEANING AND PAINTING

A. Prior to final inspection and acceptance of the plant and facilities for beneficial use by the Government, the plant facilities, equipment and systems shall be thoroughly cleaned and painted.
   1. Refer to Section 09 91 14, EXTERIOR PAINTING or Section 09 91 24, INTERIOR PAINTING.

B. In addition, the following special conditions apply:
   1. Cleaning shall be thorough. Solvents, cleaning materials and methods recommended by the manufacturers shall be used for the specific tasks. All rust shall be removed prior to painting and from surfaces to remain unpainted. Repair scratches, scuffs, and abrasions prior to applying prime and finish coats.
   2. The following material and equipment shall not be painted:
      a. Motors, controllers, control switches, and safety switches.
      b. Control and interlock devices.

c. Regulators.
d. Control valves and thermostatic elements.
e. Lubrication devices and grease fittings.
f. Copper, brass, aluminum, stainless steel and bronze surfaces.
g. Valve stems and rotating shafts.
h. Pressure gauges and thermometers.
i. Glass.
j. Nameplates.

3. Control and instrument panels shall be cleaned, damaged surfaces repaired, and shall be touched-up with matching paint obtained from panel manufacturer.
4. Temporary Facilities: Apply paint to surfaces that do not have existing finish coats. This may include painting exposed metals where hangers were removed or where equipment was moved or removed.
5. Final result shall be smooth, even-colored, even-textured factory finish on all items. Completely repaint the entire piece of equipment if necessary to achieve this.
6. Lead based paints are prohibited.

3.8 IDENTIFICATION SIGNS

A. Provide laminated plastic signs, with engraved lettering not less than 5 mm (3/16 inch) high, designating functions, for all equipment, switches, motor controllers, relays, meters, control devices, including automatic control valves. Nomenclature and identification symbols shall correspond to that used in maintenance manual, and in diagrams specified elsewhere. Attach by chain, adhesive, or screws.
B. Factory Built Equipment: Metal plate, securely attached, with name and address of manufacturer, serial number, model number, size, performance.
C. Pipe Identification: Adhesive-backed pipe markers.
D. Attach ceiling grid label on ceiling grid frame or access panel door or frame location directly underneath above-ceiling mechanical equipment and components such as control system equipment, valves, filter units, fans, air handling equipment, fire smoke dampers, and air terminal units.

1. Labels shall be digitally-printed adhesive vinyl.

E. Coordination with Existing Identification:

1. Final identification of ductwork, piping, valves, equipment, and accessories shall match the existing identification scheme used in the facility. Identification scheme shall be approved by the COR.

3.9 MOTOR AND DRIVES

A. Use synchronous belt drives only on equipment controlled by soft starters or variable frequency drive motor controllers without a bypass contactor. Use V-belt drives on all other applications.

B. Alignment of V-Belt Drives: Set driving and driven shafts parallel and align so that the corresponding grooves are in the same plane.

C. Alignment of Synchronous Belt Drives: Set driving and driven shafts parallel and align so that the corresponding pulley flanges are in the same plane.

D. Alignment of Direct-Connect Drives: Securely mount motor in accurate alignment so that shafts are per coupling manufacturer’s tolerances when both motor and driven machine are operating at normal temperatures.

3.10 LUBRICATION

A. All equipment and devices requiring lubrication shall be lubricated prior to initial operation. Field-check all devices for proper lubrication.

B. All devices and equipment shall be equipped with required lubrication fittings or devices. A minimum of 0.95 liter (1 quart) of oil and 0.45 kg (1 pound) of grease of manufacturer's recommended grade and type for each different application shall be provided; also provide 12 grease sticks for lubricated plug valves. Deliver all materials to COR in unopened containers that are properly identified as to application.

C. All lubrication points shall be accessible without disassembling equipment, except to remove access plates.

D. All lubrication points shall be extended to one side of the equipment.

3.11 STARTUP, TEMPORARY OPERATION AND TESTING

A. Perform tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.

B. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.

C. The Commissioning Agent will observe startup and Contractor testing of selected equipment. Coordinate the startup and Contractor testing schedules with COR and Commissioning Agent. Provide a minimum notice of 10 working days prior to startup and testing.

D. Startup of equipment shall be performed as described in equipment specifications. Vibration within specified tolerance shall be verified prior to extended operation. Temporary use of equipment is specified in Section 01 00 00, GENERAL REQUIREMENTS, Article, TEMPORARY USE OF MECHANICAL AND ELECTRICAL EQUIPMENT.

3.12 OPERATING AND PERFORMANCE TESTS

A. Prior to the final inspection, perform required tests as specified in Section 01 00 00, GENERAL REQUIREMENTS Article, TESTS, and in individual Division 23 specification sections and submit the test reports and records to the COR.

B. Should evidence of malfunction in any tested system, or piece of equipment or component part thereof, occur during or as a result of tests, make proper corrections, repairs or replacements, and repeat tests at no additional cost or time to the Government.

C. When completion of certain work or system occurs at a time when final control settings and adjustments cannot be properly made to make performance tests, then conduct such performance tests and finalize control settings for heating systems and for cooling systems respectively during first actual seasonal use of respective systems following completion of work. Rescheduling of these tests shall be requested in writing to COR for approval.

D. No adjustments may be made during the acceptance inspection. All adjustments shall have been made by this point.

E. Perform tests as required for commissioning provisions in accordance with Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS and Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

3.13 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

B. Components provided under this section of the specification will be tested as part of a larger system.

3.14 DEMONSTRATION AND TRAINING

A. Refer to individual specification sections for training required to be provided for each specific system.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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SECTION 23 05 12
GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, installation and connection of motors for HVAC equipment.

B. A complete listing of common acronyms and abbreviations are included in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

1.2 RELATED WORK

A. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

D. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

E. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

F. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES.

1.3 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Where conflicts occur these specifications and the VA standard will govern.

B. American Bearing Manufacturers Association (ABMA):

1. 9- 2015 Load Ratings and Fatigue Life for Ball Bearings
2. 11-2015-2014 Load Ratings and Fatigue Life for Roller Bearings

C. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):

1. 90.1-2013 Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings

D. Institute of Electrical and Electronics Engineers (IEEE):

1. 112-2017 Standard Test Procedure for Polyphase Induction Motors and Generators

2. 841-2009 IEEE Standard for Petroleum and Chemical Industry-Premium-Efficiency, Severe-Duty, Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors-Up to and Including 370 kW (500 hp)

E. National Electrical Manufacturers Association (NEMA):
   1. MG 1-2019 Motors and Generators
   2. MG 2- 2014 Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators
   3. 250-2014 Enclosures for Electrical Equipment (1000 Volts Maximum)

F. National Fire Protection Association (NFPA):
   1. 70-2020 National Electrical Code (NEC)

1.4 SUBMITTALS

A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Information and material submitted under this section shall be marked '' SUBMITTED UNDER SECTION 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT'' , with applicable paragraph identification.

C. Submit motor submittals with driven equipment.

D. Shop Drawings:
   1. Provide documentation to demonstrate compliance with contract documents.
   2. Motor nameplate information shall be submitted including electrical ratings, efficiency, bearing data, power factor, frame size, dimensions, mounting details, materials, horsepower, voltage, phase, speed (RPM), enclosure, starting characteristics, torque characteristics, code letter, full load and locked rotor current, service factor, and lubrication method.

E. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.

F. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replacement parts, and troubleshooting guide:
   1. Include complete list indicating all components of the systems.
   2. Include complete diagrams of the internal wiring for each item of equipment.
   3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

G. Certification: Two weeks prior to final inspection, unless otherwise noted, certification shall be submitted to the COR stating that the motors have been properly applied, installed, adjusted, lubricated, and tested.

H. Completed System Readiness Checklist provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

I. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

1.5 AS-BUILT DOCUMENTATION

A. Submit manufacturer’s literature and data updated to include submittal review comments and any equipment substitutions.

B. Submit operation and maintenance data updated to include submittal review comments, VA approved substitutions and construction revisions shall be in electronic version on CD or DVD inserted into a three-ring binder. All aspects of system operation and maintenance procedures, including applicable piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices shall be included. A List of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.

C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the 'third party testing company' requirement. Provide record drawings as follows:

   1. As-built drawings are to be provided, with a copy of them on AutoCAD version 2018 or newer provided on CD or DVD. The CAD drawings shall use multiple line layers with a separate individual layer for each system.

D. The as-built drawings shall indicate the location and type of all lockout/tagout points for all energy sources for all equipment and pumps to include breaker location and numbers, valve tag numbers, etc. Coordinate lockout/tagout procedures and practices with local VA requirements.

E. Certification documentation shall be provided to COR 21 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and provide documentation/certification that all results of tests were within limits specified. Test results shall contain written sequence of test procedure with written test results annotated at each step along with the expected outcome or setpoint. The results shall include all readings, including but not limited to data on device (make, model and performance characteristics), normal pressures, switch ranges, trip points, amp readings, and calibration data to include equipment serial numbers or individual identifications, etc.

PART 2 - PRODUCTS

2.1 MOTORS

A. For alternating current, fractional and integral horsepower motors, NEMA MG 1 and NEMA MG 2 shall apply.

B. For severe duty TEFC motors, IEEE 841 shall apply.

C. All material and equipment furnished and installation methods shall conform to the requirements of Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES. Provide all electrical wiring, conduit, and devices necessary for the proper connection, protection and operation of the systems. Provide premium efficiency type motors. Unless otherwise specified for a particular application, use electric motors with the following requirements.

D. Single-phase Motors: Motors for centrifugal fans and pumps may be split phase or permanent split capacitor (PSC) type. Provide capacitor-start type for hard starting applications.

E. Poly-phase Motors: NEMA Design B, Squirrel cage, induction type.

1. Two Speed Motors: Each two-speed motor shall have two separate windings. Provide a time- delay (20 seconds minimum) relay for switching from high to low speed.

F. Voltage ratings shall be as follows:

1. Single phase:
    a. Motors connected to 120-volt systems: 115 volts.
    b. Motors connected to 208-volt systems: 200 volts.
2. Three phase:
    a. Motors connected to 208-volt systems: 200 volts.
    b. Motors, less than 74.6 kW (100 hp), connected to 240-volt or 480-volt systems: 208-230/460 volts, dual connection.

G. Number of phases shall be as follows:
1. Motors, less than 373 W (1/2 hp): Single phase.
2. Motors, 373 W (1/2 hp) and larger: 3 phase.
3. Exceptions:
    a. Hermetically sealed motors.
    b. Motors for equipment assemblies, less than 746 W (1 hp), may be single phase provided the manufacturer of the proposed assemblies cannot supply the assemblies with three phase motors.

H. Horsepower ratings shall be adequate for operating the connected loads continuously in the prevailing ambient temperatures in areas where the motors are installed, without exceeding the NEMA standard temperature rises for the motor insulation.

I. Motor designs, as indicated by the NEMA code letters, shall be coordinated with the connected loads to assure adequate starting, acceleration, and running torque without exceeding nameplate ratings or considering service factor.

J. Motor Enclosures:
1. Shall be the NEMA types as specified and/or shown in the Contract Documents.
2. Where the types of motor enclosures are not shown on the drawings, they shall be the NEMA types per NEMA 250, which are most suitable for the environmental conditions where the motors are being installed. Enclosure requirements for certain conditions are as follows:

a. Motors located outdoors, indoors in wet or high humidity locations, or in unfiltered airstreams shall be totally enclosed type.
b. Where motors are located in an NEC 511 classified area, provide TEFC explosion proof motor enclosures.
c. Where motors are located in a corrosive environment, provide TEFC enclosures with corrosion resistant finish.

3. Enclosures shall be primed and finish coated at the factory with manufacturer's prime coat and standard finish.

K. Electrical Design Requirements:

1. Motors shall be continuous duty.
2. The insulation system shall be rated minimum of Class B, 130 degrees C (266 degrees F).
3. The maximum temperature rise by resistance at rated power shall not exceed Class B limits, 80 degrees C (176 degrees F).
4. The speed/torque and speed/current characteristics shall comply with NEMA Design A or B, as specified.
5. Motors shall be suitable for full voltage starting, unless otherwise noted. Coordinate motor features with applicable motor controllers.
6. Motors for variable frequency drive applications shall adhere to NEMA MG 1, Part 30, Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General-Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both, or NEMA MG 1, Part 31, Definite-Purpose Inverter-Fed Polyphase Motors.

L. Mechanical Design Requirements:

1. Bearings shall be rated in accordance with ABMA 9 or ABMA 11 for a minimum fatigue life of 26,280 hours for belt-driven loads and 100,000 hours for direct-drive loads based on L10 (Basic Rating Life) at full load direct coupled, except vertical high thrust motors which require a 40,000 hours rating. A minimum fatigue life of 40,000 hours is required for VFD drives.

2. Vertical motors shall be capable of withstanding a momentary up thrust of at least 30 percent of normal down thrust.
3. Grease lubricated bearings shall be designed for electric motor use. Grease shall be capable of the temperatures associated with electric motors and shall be compatible with Polyurea based greases.
4. Grease fittings, if provided, shall be Alemite type or equivalent.
5. Oil lubricated bearings, when specified, shall have an externally visible sight glass to view oil level.
6. Vibration shall not exceed 3.8 mm (0.15 inch) per second, unfiltered peak.
7. Noise level shall meet the requirements of the application.
8. Motors on 180 frames and larger shall have provisions for lifting eyes or lugs capable of a safety factor of 5.
9. All external fasteners shall be corrosion resistant.
10. Condensation heaters, when specified, shall keep motor windings at least 5 degrees C (9 degrees F) above ambient temperature.
11. Winding thermostats, when specified shall be normally closed, connected in series.
12. Grounding provisions shall be in the main terminal box.

M. Special Requirements:
1. Where motor power requirements of equipment furnished deviate from power shown on plans, provide electrical service designed under the requirements of NFPA 70 without additional cost or time to the Government.
2. Assemblies of motors, starters, controls and interlocks on factory assembled and wired devices shall be in accordance with the requirements of this specification.
3. Wire and cable materials specified in the electrical division of the specifications shall be modified as follows:
   a. Wiring material located where temperatures can exceed 71 degrees C (160 degrees F) shall be stranded copper with Teflon FEP insulation with jacket. This includes wiring on the boilers.

b. Other wiring at boilers and to control panels shall be NFPA 70 designation THWN.
c. Provide shielded conductors or wiring in separate conduits for all instrumentation and control systems where recommended by manufacturer of equipment.

4. Select motor sizes so that the motors do not operate into the service factor at maximum required loads on the driven equipment. Motors on pumps shall be sized for non-overloading at all points on the pump performance curves.
5. Motors utilized with variable frequency drives shall be rated "inverter-duty" per NEMA MG 1, Part 31, Definite-Purpose Inverter-Fed Polyphase Motors. Provide motor shaft grounding apparatus that will protect bearings from damage from stray currents.

N. Additional requirements for specific motors, as indicated in the other sections listed in Article, RELATED SECTIONS shall also apply.
O. NEMA Premium Efficiency Electric Motors (Motor Efficiencies): All permanently wired polyphase motors of 746 W (1 hp) or more shall meet the minimum full-load efficiencies as indicated in the following table. Motors of 746 W (1 hp) or more with open, drip-proof, or TEFC enclosures shall be NEMA premium efficiency type, unless otherwise indicated. Motors provided as an integral part of motor driven equipment are excluded from this requirement if a minimum seasonal or overall efficiency requirement is indicated for that equipment by the provisions of another section.
P. Minimum Power Factor at Full Load and Rated Voltage: 90 percent at 1200 RPM, 1800 RPM, and 3600 RPM. Power factor correction capacitors shall be provided unless the motor meets the 0.90 requirement without it or if the motor is controlled by a variable frequency drive. The power factor correction capacitors shall be able to withstand high voltage transients and power line variations without breakdown.
Q. Energy Efficiency of Small Motors (Motor Efficiencies): All motors under 746 W (1 hp) shall meet the requirements of the DOE Small Motor Regulation.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install motors in accordance with manufacturer's recommendations, the NEC, NEMA, as shown on the drawings and/or as required by other sections of these specifications.

B. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no additional cost or time to the Government.

3.2 FIELD TESTS

A. All tests shall be witnessed by the Commissioning Agent or by the COR.

B. Perform an electric insulation resistance Test using a megohmmeter on all motors after installation, before startup. All shall test free from grounds.

C. Perform Load test in accordance with IEEE 112, Test Method B, to determine freedom from electrical or mechanical defects and compliance with performance data.

D. Insulation Resistance: Not less than one-half meg-ohm between stator conductors and frame, to be determined at the time of final inspection.

E. All test data shall be complied into a report form for each motor and provided to the COR.

3.3 STARTUP AND TESTING

A. Perform tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.

B. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.

C. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with COR and Commissioning Agent. Provide a minimum notice of 10 working days prior to startup and testing.

3.4 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

B. Components provided under this section of the specification will be tested as part of a larger system.

3.5 DEMONSTRATION AND TRAINING

A. Training on components provided under this section will be provided as part of other systems.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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SECTION 23 05 41
NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. Noise criteria, seismic restraints for equipment, vibration tolerance and vibration isolation for HVAC and plumbing work.

1.2 RELATED WORK

A. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA and SAMPLES.
B. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
C. Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.
D. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

1.3 QUALITY ASSURANCE

A. Refer to article, QUALITY ASSURANCE in specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
B. Noise Criteria:
   1. Noise levels in all 8 octave bands due to equipment and duct systems shall not exceed following NC levels:

      \ul Type of Room NC Level

      a. Offices, Large Open 40
      b. Offices, Small Private 35
      c. Shops 50
      d. General Work Rooms 40

   2. For equipment which has no sound power ratings scheduled on the plans, the contractor shall select equipment such that the foregoing noise criteria, local ordinance noise levels, and OSHA requirements are not exceeded. Selection procedure shall be in accordance with ASHRAE Fundamentals Handbook, Chapter 7, Sound and Vibration.

3. An allowance, not to exceed 5db, may be added to the measured value to compensate for the variation of the room attenuating effect between room test condition prior to occupancy and design condition after occupancy which may include the addition of sound absorbing material, such as, furniture. This allowance may not be taken after occupancy. The room attenuating effect is defined as the difference between sound power level emitted to room and sound pressure level in room.
4. In absence of specified measurement requirements, measure equipment noise levels three feet from equipment and at an elevation of maximum noise generation.

C. Seismic Restraint Requirements:
1. Refer to Section 13 05 41, SEISMIC RESTRAINT FOR NON-STRUCTURAL COMPONENTS.
2. Equipment:
a. All mechanical equipment not supported with isolators external to the unit shall be securely anchored to the structure. Such mechanical equipment shall be properly supported to resist a horizontal force of 20 percent of the weight of the equipment furnished.
b. All mechanical equipment mounted on vibration isolators shall be provided with seismic restraints capable of resisting a horizontal force of 100 percent of the weight of the equipment furnished.
3. Piping: Refer to specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

1.4 SUBMITTALS

A. Submit in accordance with specification Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
B. Manufacturer's Literature and Data:
1. Vibration isolators:
a. Floor mountings
b. Hangers
c. Snubbers
d. Thrust restraints

e. Bases.

f. Seismic restraint provisions and bolting.

g. Acoustical enclosures.

2. Isolator manufacturer shall furnish with submittal load calculations for selection of isolators, including supplemental bases, based on lowest operating speed of equipment supported.

C. Seismic Requirements: Submittals are required for all equipment anchors, supports and seismic restraints. Submittals shall include weights, dimensions, standard connections, and manufacturer's certification that all specified equipment will withstand seismic Lateral Force requirements as shown on drawings.

1.5 APPLICABLE PUBLICATIONS

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

B. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE):

1. Fundamentals Handbook, Chapter 7, Sound and Vibration

C. American Society for Testing and Materials (ASTM):

1. A123/A123M-09 Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

2. A307-07b Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength

3. D2240-05(2010) Standard Test Method for Rubber Property - Durometer Hardness

D. Manufacturers Standardization (MSS):

1. SP-58-2009 Pipe Hangers and Supports-Materials, Design and Manufacture

E. Occupational Safety and Health Administration (OSHA):

1. 29 CFR 1910.95 Occupational Noise Exposure

F. American Society of Civil Engineers (ASCE):

1. ASCE 7-10 Minimum Design Loads for Buildings and Other Structures.

G. American National Standards Institute / Sheet Metal and Air Conditioning Contractor’s National Association (ANSI/SMACNA):

1. 001-2008 Seismic Restraint Manual: Guidelines for Mechanical Systems, 3rd Edition.

H. International Code Council (ICC):
1. IBC-2021 International Building Code.

I. Department of Veterans Affairs (VA):
1. H-18-8 2010 Seismic Design Requirements.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Type of isolator, base, and minimum static deflection shall be as required for each specific equipment application as recommended by isolator or equipment manufacturer but subject to minimum requirements indicated herein and in the schedule on the drawings.

B. Elastometric Isolators shall comply with ASTM D2240 and be oil resistant neoprene with a maximum stiffness of 60 durometer and have a straight-line deflection curve.

C. Exposure to weather: Isolator housings to be either hot dipped galvanized or powder coated to ASTM B117 salt spray testing standards. Springs to be powder coated or electro galvanized. All hardware to be electro galvanized. In addition provide limit stops to resist wind velocity. Velocity pressure established by wind shall be calculated in accordance with section 1609 of the International Building Code. A minimum wind velocity of 75 mph shall be employed.

D. Uniform Loading: Select and locate isolators to produce uniform loading and deflection even when equipment weight is not evenly distributed.

E. Color code isolators by type and size for easy identification of capacity.

2.2 SEISMIC RESTRAINT REQUIREMENTS FOR EQUIPMENT

A. Bolt pad mounted equipment, without vibration isolators, to the floor or other support using ASTM A307 standard bolting material.

B. Floor mounted equipment, with vibration Isolators: Type SS. Where Type N isolators are used provide channel frame base horizontal restraints bolted to the floor, or other support, on all sides of the equipment Size and material required for the base shall be as recommended by the isolator manufacturer.

C. On all sides of suspended equipment, provide bracing for rigid supports and provide restraints for resiliently supported equipment.

2.3 VIBRATION ISOLATORS

A. Floor Mountings:

1. Spring Isolators (Type S): Shall be free-standing, laterally stable and include acoustical friction pads and leveling bolts. Isolators shall have a minimum ratio of spring diameter-to-operating spring height of 1.0 and an additional travel to solid equal to 50 percent of rated deflection.
2. Captive Spring Mount for Seismic Restraint (Type SS):
   a. Design mounts to resiliently resist seismic forces in all directions. Snubbing shall take place in all modes with adjustment to limit upward, downward, and horizontal travel to a maximum of 6 mm (1/4-inch) before contacting snubbers. Mountings shall have a minimum rating of one G coefficient of gravity as calculated and certified by a registered structural engineer.
   b. All mountings shall have leveling bolts that must be rigidly bolted to the equipment. Spring diameters shall be no less than 0.8 of the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal to 50 percent of the rated deflection. Mountings shall have ports for spring inspection. Provide an all directional neoprene cushion collar around the equipment bolt.

B. Hangers: Shall be combination neoprene and springs unless otherwise noted and shall allow for expansion of pipe.

1. Combination Neoprene and Spring (Type H): Vibration hanger shall contain a spring and double deflection neoprene element in series. Spring shall have a diameter not less than 0.8 of compressed operating spring height. Spring shall have a minimum additional travel of 50 percent between design height and solid height. Spring shall permit a 15 degree angular misalignment without rubbing on hanger box.
2. Spring Position Hanger (Type HP): Similar to combination neoprene and spring hanger except hanger shall hold piping at a fixed elevation during installation and include a secondary adjustment feature to transfer load to spring while maintaining same position.
3. Neoprene (Type HN): Vibration hanger shall contain a double deflection type neoprene isolation element. Hanger rod shall be separated from contact with hanger bracket by a neoprene grommet.
4. Spring (Type HS): Vibration hanger shall contain a coiled steel spring in series with a neoprene grommet. Spring shall have a diameter not less than 0.8 of compressed operating spring height. Spring shall have a minimum additional travel of 50 percent between design height and solid height. Spring shall permit a 15 degree angular misalignment without rubbing on hanger box.
5. Hanger supports for piping 50 mm (2 inches) and larger shall have a pointer and scale deflection indicator.
6. Hangers used in seismic applications shall be provided with a neoprene and steel rebound washer installed ¼″ clear of bottom of hanger housing in operation to prevent spring from excessive upward travel

PART 3 - EXECUTION

3.1 INSTALLATION

A. Vibration Isolation:

1. No metal-to-metal contact will be permitted between fixed and floating parts.

2. Connections to Equipment: Allow for deflections equal to or greater than equipment deflections. Electrical, drain, piping connections, and other items made to rotating or reciprocating equipment (pumps, compressors, etc.) which rests on vibration isolators, shall be isolated from building structure for first three hangers or supports with a deflection equal to that used on the corresponding equipment.
3. Common Foundation: Mount each electric motor on same foundation as driven machine. Hold driving motor and driven machine in positive rigid alignment with provision for adjusting motor alignment and belt tension. Bases shall be level throughout length and width. Provide shims to facilitate pipe connections, leveling, and bolting.
4. Provide heat shields where elastomers are subject to temperatures over 38 degrees C (100 degrees F).
5. Extend bases for pipe elbow supports at discharge and suction connections at pumps. Pipe elbow supports shall not short circuit pump vibration to structure.

B. Inspection and Adjustments: Check for vibration and noise transmission through connections, piping, ductwork, foundations, and walls. Adjust, repair, or replace isolators as required to reduce vibration and noise transmissions to specified levels.

3.2 ADJUSTING

A. Adjust vibration isolators after piping systems are filled and equipment is at operating weight.
B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
C. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4inch (6-mm) movement during start and stop.
D. Adjust active height of spring isolators.
E. Adjust snubbers according to manufacturer's recommendations.
F. Adjust seismic restraints to permit free movement of equipment within normal mode of operation.

G. Torque anchor bolts according to equipment manufacturer's recommendations to resist seismic forces.

3.3 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.

B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

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SECTION 23 05 93
TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 DESCRIPTION

A. Testing, adjusting, and balancing (TAB) of heating, ventilating and air conditioning (HVAC) systems. TAB includes the following:
   1. Planning systematic TAB procedures.
   2. Design Review Report.
   3. Preliminary air flow readings (taken prior to any system modifications):
      a. Air inlets & outlets in all spaces to be modified.
   4. Systems Inspection report.
   5. Duct Air Leakage test report.
   6. Systems Readiness Report.
   7. Balancing air and water distribution systems including plumbing systems; adjustment of total system to provide design performance; and testing performance of equipment and automatic controls.
   8. Vibration and sound measurements.
   9. Recording and reporting results.
   10. Document critical paths of flow on reports.

1.2 DEFINITIONS:

A. Basic TAB used in this Section: Chapter 39, "Testing, Adjusting and Balancing" of 2019 ASHRAE Handbook, "HVAC Applications".
B. TAB: Testing, Adjusting and Balancing; the process of checking and adjusting HVAC systems to meet design objectives.
C. AABC: Associated Air Balance Council.
D. NEBB: National Environmental Balancing Bureau.
E. TABB: Testing Adjusting and Balancing Bureau.
F. SMACNA: Sheet Metal Contractors National Association.
G. Air Systems: Includes all outside air, supply air, return air, exhaust air, and relief air systems.
H. Flow rate tolerance: The allowable percentage variation, minus to plus, of actual flow rate from values (design) in the contract documents.

1.3 RELATED WORK

A. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
B. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.
C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
D. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
E. Section 23 07 11, HVAC AND BOILER PLANT INSULATION.
F. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
G. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
H. Section 23 21 13, HYDRONIC PIPING.
I. Section 23 31 00, HVAC DUCTS AND CASINGS.

1.4 QUALITY ASSURANCE

A. Refer to Articles, Quality Assurance and Submittals, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
B. Qualifications:
   1. TAB Agency: The TAB agency shall be a subcontractor of the General Contractor and shall report to and be paid by the General Contractor.
   2. The TAB agency shall be either a certified member of AABC, NEBB, or TABB to perform TAB service for HVAC, water balancing and vibrations and sound testing of equipment. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason, the agency loses subject certification during this period, the General Contractor shall immediately notify the COR and submit another qualified TAB firm for approval. Any agency that has been the subject of disciplinary action by either AABC, NEBB, or TABB within the five years preceding Contract Award shall not be eligible to perform any work related to the TAB. All work performed in this Section and in other related Sections by the TAB agency shall be considered invalid if the TAB agency loses its certification prior to Contract completion, and the successor agency’s review shows unsatisfactory work performed by the predecessor agency.

3. TAB Specialist: The TAB specialist shall be either a member of AABC, NEBB, or TABB or an experienced technician of the Agency certified by AABC, NEBB, or TABB. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason, the Specialist loses subject certification during this period, the General Contractor shall immediately notify the COR and submit another TAB Specialist for approval. Any individual that has been the subject of disciplinary action by either AABC, NEBB, or TABB within the five years preceding Contract Award shall not be eligible to perform any duties related to the HVAC systems, including TAB. All work specified in this Section and in other related Sections performed by the TAB specialist shall be considered invalid if the TAB Specialist loses its certification prior to Contract completion and must be performed by an approved successor.
4. TAB Specialist shall be identified by the General Contractor within 60 days after the notice to proceed. The TAB specialist will be coordinating, scheduling and reporting all TAB work and related activities and will provide necessary information as required by the COR. The responsibilities would specifically include:
    a. Shall directly supervise all TAB work.
    b. Shall sign the TAB reports that bear the seal of the TAB standard. The reports shall be accompanied by report forms and schematic drawings required by the TAB standard, AABC, NEBB, or TABB.
    c. Would follow all TAB work through its satisfactory completion.
    d. Shall provide final markings of settings of all HVAC adjustment devices.
    e. Permanently mark location of duct test ports.
    f. Shall document critical paths from the fan or pump. These critical paths are ones which are 100% open from the fan or pump to the terminal device. This will show the least amount of restriction is being imposed on the system by the TAB firm.

5. All TAB technicians performing actual TAB work shall be experienced and must have done satisfactory work on a minimum of 3 projects comparable in size and complexity to this project. Qualifications must be certified by the TAB agency in writing. The lead technician shall be certified by AABC, NEBB, or TABB.

C. Test Equipment Criteria: The instrumentation shall meet the accuracy/calibration requirements established by AABC National Standards, TABB/SMACNA International Standards, or NEBB Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems and instrument manufacturer. Provide calibration history of the instruments to be used for test and balance purpose.

D. Tab Criteria:

1. One or more of the applicable AABC, NEBB, TABB, or SMACNA publications, supplemented by ASHRAE Handbook "2019 HVAC Applications" Chapter 39, and requirements stated herein shall be the basis for planning, procedures, and reports.
2. Flow rate tolerance: The following tolerances are allowed. For tolerances not mentioned herein follow ASHRAE Handbook "2019 HVAC Applications", Chapter 39, as a guideline. Air Filter resistance during tests, artificially imposed if necessary, shall be at least 100 percent of manufacturer recommended change over pressure drop values for pre-filters and after-filters.
   a. Air handling unit and all other fans, cubic meters/min (cubic feet per minute): Minus 0 percent to plus l0 percent.
   b. Individual room air outlets and inlets, and air flow rates not mentioned above: Minus 5 percent to plus l0 percent except if the air to a space is 100 CFM or less the tolerance would be minus 5 to plus 5 percent.
   c. Heating hot water pumps and hot water coils: Minus 5 percent to plus 5 percent.
   d. Chilled water and condenser water pumps: Minus 0 percent to plus 5 percent.
   e. Chilled water coils: Minus 0 percent to plus 5 percent.
3. Systems shall be adjusted for energy efficient operation as described in PART 3.

4. Typical TAB procedures and critical path results shall be demonstrated to the COR as follows:
   a. When field TAB work begins.
   b. During each partial final inspection and the final inspection for the project if requested by the COR.
   c. Air systems: Demonstrate one air distribution system (including all all fans, up to three terminal units, and up to three rooms as randomly selected by the COR).
      1) One of the selected rooms shall be a critical path.
   d. Hydronic systems: Demonstrate one hydronic system (including all pumps and up to three coils as randomly selected by the COR).

1.5 SUBMITTALS

A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.

B. Submit names and qualifications of TAB agency and TAB specialists within 60 days after the notice to proceed. Submit information on three recently completed projects and a list of proposed test equipment.

C. For use by the COR, submit one complete set of applicable AABC, NEBB, or TABB publications that will be the basis of TAB work.

D. Submit Following for Review and Approval:
   1. Design Review Report within 90 days for conventional design projects after the system layout on air side is completed by the Contractor.
   2. Systems inspection report on equipment and installation for conformance with design.
   3. Duct Air Leakage Test Report.
   4. Systems Readiness Report.
   5. Intermediate and Final TAB reports covering flow balance and adjustments and performance tests.
   6. Include in final reports uncorrected installation deficiencies noted during TAB and applicable explanatory comments on test results that differ from design requirements.

7. Include in each report the critical path for each balanced branch (air and hydronic). Every critical path branch shall have at least one terminal device (damper or valve) set to 100% open.

E. Prior to request for Final or Partial Final inspection, submit completed Test and Balance report for the area with noted critical paths.

1.6 APPLICABLE PUBLICATIONS

A. The following publications form a part of this specification to the extent indicated by the reference thereto. In text the publications are referenced to by the acronym of the organization.

B. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE):

1. HVAC Applications ASHRAE Handbook 2019, Chapter 39, Testing, Adjusting, and Balancing and Chapter 49, Sound and Vibration Control

C. Associated Air Balance Council (AABC):

1. 7th Edition 2016, AABC National Standards for Total System Balance

D. National Environmental Balancing Bureau (NEBB):

1. 9th Edition 2019 Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems
2. 3rd Edition 2015 Procedural Standards for the Measurement of Sound and Vibration
3. 2nd Edition 2019 Procedural Standards for Whole Building Technical Commissioning of New Construction

E. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):

1. 3rd Edition 2005 HVAC SYSTEMS Testing, Adjusting and Balancing

F. Testing Adjusting and Balancing Bureau (TABB):

1. TAB Procedural Guide (current edition)

PART 2 - PRODUCTS

2.1 PLUGS

A. Provide plastic plugs to seal holes drilled in ductwork for test purposes.

2.2 INSULATION REPAIR MATERIAL

A. See Section 23 07 11, HVAC and BOILER PLANT INSULATION Provide for repair of insulation removed or damaged for TAB work.

PART 3 - EXECUTION

3.1 GENERAL

A. Refer to TAB Criteria in Article, Quality Assurance.

B. Obtain applicable contract documents and copies of approved submittals for HVAC equipment and automatic control systems.

3.2 DESIGN REVIEW REPORT

A. The TAB Specialist shall review the Contract Plans and specifications and advise the COR of any design deficiencies that would prevent the HVAC systems from effectively operating in accordance with the sequence of operation specified or prevent the effective and accurate TAB of the system. The TAB Specialist shall provide a report individually listing each deficiency and the corresponding proposed corrective action necessary for proper system operation.

B. The Design Review Report shall include preliminary air flow readings (taken prior to any system modifications).

1. All existing air inlets & outlets in all modified spaces.

3.3 SYSTEMS INSPECTION REPORT

A. Inspect equipment and installation for conformance with design.

B. The inspection and report is to be done after air distribution equipment is on site and duct installation has begun, but well in advance of performance testing and balancing work. The purpose of the inspection is to identify and report deviations from design and ensure that systems will be ready for TAB at the appropriate time.

C. Reports: Follow check list format developed by AABC, NEBB, TABB, or SMACNA, supplemented by narrative comments, with emphasis on air handling units and fans. Check for conformance with submittals. Verify that diffuser and register sizes are correct. Check air terminal unit installation including their duct sizes and routing.

3.4 DUCT AIR LEAKAGE TEST REPORT

A. TAB Agency shall perform the leakage test as outlined in "Duct leakage Tests and Repairs" in Section 23 31 00, HVAC DUCTS and CASINGS for TAB agency's role and responsibilities in witnessing, recording and reporting of deficiencies.

3.5 SYSTEM READINESS REPORT

A. The TAB Contractor shall measure existing air and water flow rates associated with existing systems utilized to serve renovated areas as indicated on drawings. Submit report of findings to the COR.

B. Inspect each System to ensure that it is complete including installation and operation of controls.

1. Submit report to COR in standard format and forms prepared and or approved by the Commissioning Agent.

C. Verify that all items such as ductwork, dampers, ports, terminals, connectors, and inlets and outlets, etc., that are required for TAB are installed. Provide a report to the COR.

3.6 TAB REPORTS

A. Submit an intermediate report for 25 percent of systems and equipment tested and balanced to establish satisfactory test results.

B. The TAB contractor shall provide raw data immediately in writing to the COR if there is a problem in achieving intended results before submitting a formal report.

C. If over 20 percent of readings in the intermediate report fall outside the acceptable range, the TAB report shall be considered invalid and all contract TAB work shall be repeated after engineering and construction have been evaluated and re-submitted for approval at no additional cost to the owner.

D. Do not proceed with the remaining systems until intermediate report is approved by the COR.

3.7 TAB PROCEDURES

A. TAB shall be performed in accordance with the requirement of the Standard under which TAB agency is certified by either AABC, NEBB, or TABB. Balancing shall be done proportionally to all applicable systems.

1. At least one trunk damper shall be 100% open.
2. At least one branch damper shall be 100% open per trunk.
3. At least one terminal device shall be 100% open per branch.

B. General: During TAB all related system components shall be in full operation. Fan and pump rotation, motor loads and equipment vibration shall be checked and corrected as necessary before proceeding with TAB. Set controls and/or block off parts of distribution systems to simulate design operation of variable volume air or water systems for test and balance work.

C. Coordinate TAB procedures with existing systems and any phased construction completion requirements for the project. Provide TAB reports for pre-construction air flow rate and each phase of the project prior to partial final inspections of each phase of the project.

D. Allow 30 day's time in construction schedule for TAB and submission of all reports for an organized and timely correction of deficiencies.

E. Air Balance and Equipment Test: Include fans, room diffusers/outlets/inlets, and computer room AC units.
1. Adjust fan speeds to provide design air flow. V-belt drives, including fixed pitch pulley requirements, are specified in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
2. Test and balance systems in all specified modes of operation, including variable volume, economizer, and fire emergency modes.
3. Verify that dampers and other HVAC controls function properly.
4. Record final measurements for air handling equipment performance data sheets.

F. Water Balance and Equipment Test: Include circulating pumps, converters, coils, coolers, and condensers:
1. Adjust flow rates for equipment. Set coils and evaporator to values on equipment submittals, if different from values on contract drawings.
2. Primary-secondary (variable volume) systems: Coordinate TAB with Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC. Balance systems at design water flow and then verify that variable flow controls function as designed.

3. Record final measurements for hydronic equipment on performance data sheets. Include entering and leaving water temperatures for heating and cooling coils, and for convertors. Include entering and leaving air temperatures (DB/WB for cooling coils) for air handling units and reheat coils. Make air and water temperature measurements at the same time.

3.8 VIBRATION TESTING

A. Furnish instruments and perform vibration measurements as specified in Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT. Field vibration balancing is specified in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

B. Provide measurements for all rotating HVAC equipment of 373 watts (1/2 horsepower) and larger, including fans, motors, and condensing units.

C. Record initial measurements for each unit of equipment on test forms and submit a report to the COR. Where vibration readings exceed the allowable tolerance Contractor shall be directed to correct the problem. The TAB agency shall verify that the corrections are done and submit a final report to the COR.

3.9 SOUND TESTING

A. Perform and record required sound measurements in accordance with Paragraph, QUALITY ASSURANCE in Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.
   1. Take readings in a minimum of one of each room type.
   2. Take readings in all server rooms.

B. Take measurements with a calibrated sound level meter and octave band analyzer of the accuracy required by AABC, NEBB, or TABB.

C. Sound reference levels, formulas and coefficients shall be according to 2019 ASHRAE Handbook, "HVAC Applications", Chapter 49, SOUND AND VIBRATION CONTROL.

D. Determine compliance with specifications as follows:
   1. When sound pressure levels are specified, including the NC Criteria in Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT:

a. Reduce the background noise as much as possible by shutting off unrelated audible equipment.
b. Measure octave band sound pressure levels with specified equipment "off."
c. Measure octave band sound pressure levels with specified equipment "on."
d. Use the DIFFERENCE in corresponding readings to determine the sound pressure due to equipment.
e. Sound pressure level due to equipment equals sound pressure level with equipment "on" minus FACTOR.
f. Plot octave bands of sound pressure level due to equipment for typical rooms on a graph which also shows noise criteria (NC) curves.

2. When sound power levels are specified:
a. Perform steps 1.a. thru 1.d., as above.
b. For indoor equipment: Determine room attenuating effect, i.e., difference between sound power level and sound pressure level. Determined sound power level will be the sum of sound pressure level due to equipment plus the room attenuating effect.
c. For outdoor equipment: Use directivity factor and distance from noise source to determine distance factor, i.e., difference between sound power level and sound pressure level. Measured sound power level will be the sum of sound pressure level due to equipment plus the distance factor. Use 10 meters (30 feet) for sound level location.

E. Where measured sound levels exceed specified level, the installing contractor or equipment manufacturer shall take remedial action approved by the COR and the necessary sound tests shall be repeated.
F. Test readings for sound testing could go higher than 15 percent if determination is made by the COR based on the recorded sound data.

3.10 DUCT LEAKAGE TESTING

A. Refer to Section 23 31 00, HVAC DUCTS AND CASINGS, paragraph 3.4 Duct Leakage Tests and Repair, for duct leakage testing requirememts.

3.11 MARKING OF SETTINGS

A. Following approval of Tab Final Report, the setting of all HVAC adjustment devices including valves, splitters, and dampers shall be permanently marked by the TAB Specialist so that adjustment can be restored if disturbed at any time. Style and colors used for markings shall be coordinated with the COR.

3.12 IDENTIFICATION OF TEST PORTS

A. The TAB Specialist shall permanently and legibly identify the location points of duct test ports. If the ductwork has exterior insulation, the identification shall be made on the exterior side of the insulation. All penetrations through ductwork and ductwork insulation shall be sealed to prevent air leaks and maintain integrity of vapor barrier.

3.13 B PHASING

A. Phased Projects: Testing and Balancing Work to follow project with areas shall be completed per the project phasing. Upon completion of the project all areas shall have been tested and balanced per the contract documents.

B. Existing Areas: Systems that serve areas outside of the project scope shall not be adversely affected. Measure existing parameters where shown to document system capacity.

3.14 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.

B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

3.15 CRITICAL FLOW PATHS

A. Provide a documented critical path for all air and fluid flows. There shall be at least one terminal device that can be traced back to the fan or pump where there are no dampers or valves that are less than 100% open.

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SECTION 23 07 11
HVAC AND BOILER PLANT INSULATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. Field applied insulation for thermal efficiency and condensation control for
   1. HVAC piping and ductwork.

B. Definitions
   1. ASJ: All service jacket, white finish facing or jacket.
   2. Air conditioned space: Space having air temperature and/or humidity controlled by mechanical equipment.
   3. Cold: Equipment, ductwork or piping handling media at design temperature of 16 degrees C (60 degrees F) or below.
   4. Concealed: Ductwork and piping above ceilings and in chases, interstitial spaces, and pipe spaces.
   5. Exposed: Piping, ductwork, and equipment exposed to view in finished areas including mechanical rooms and electrical equipment rooms or exposed to outdoor weather. Attics and crawl spaces where air handling units are located are considered to be mechanical rooms. Spaces such as shafts, chases, interstitial spaces, unfinished attics, crawl spaces, and pipe basements are not considered finished areas.
   6. FSK: Foil-scrim-kraft facing.
   7. Hot:
      a. HVAC Ductwork handling air at design temperature above 16 degrees C (60 degrees F)
      b. HVAC equipment or piping handling media above 41 degrees C (105 degrees F)
      c. Piping media and equipment 32 to 230 degrees C(90 to 450 degrees F)
   8. Density: kg/m3 - kilograms per cubic meter (Pcf - pounds per cubic foot).
   9. Runouts: Branch pipe connections up to 25-mm (one-inch) nominal size to fan coil units or reheat coils for terminal units.
   10. Thermal conductance: Heat flow rate through materials.

a. Flat surface: Watt per square meter (BTU per hour per square foot).
b. Pipe or Cylinder: Watt per square meter (BTU per hour per linear foot).

11. Thermal Conductivity (k): Watt per meter, per degree C (BTU per inch thickness, per hour, per square foot, per degree F temperature difference).
12. Vapor Retarder (Vapor Barrier): A material which retards the transmission (migration) of water vapor. Performance of the vapor retarder is rated in terms of permeance (perms). For the purpose of this specification, vapor retarders shall have a maximum published permeance of 0.1 perms and vapor barriers shall have a maximum published permeance of 0.001 perms.
13. MPS: Medium pressure steam (110 kPa [16 psig] thru 414 kPa [59 psig].
14. MPR: Medium pressure steam condensate return.
15. LPS: Low pressure steam (103 kPa [15 psig] and below).
16. LPR: Low pressure steam condensate gravity return.
17. CH: Chilled water supply.
18. CHR: Chilled water return.
19. RS: Refrigerant suction.
20. PVDC: Polyvinylidene chloride vapor retarder jacketing, white.

1.2 BRELATED WORK

A. Section 07 84 00, JOINT FIRESTOPPING.
B. Section 07 84 13, PENETRATION FIRESTOPPING.
C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
D. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.
E. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
F. Section 23 21 13, HYDRONIC PIPING.
G. Section 23 22 13, STEAM and CONDENSATE HEATING PIPING.
H. Section 23 23 00, REFRIGERANT PIPING.
I. Section 23 31 00, HVAC DUCTS AND CASINGS.

1.3 QUALITY ASSURANCE

A. Refer to article QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

B. Criteria:

1. Comply with NFPA 90A, particularly paragraphs 4.3.3.1 through 4.3.3.6, 4.3.10.2.6, and 5.4.6.4, parts of which are quoted as follows:

a. 4.3.3.1 Pipe insulation and coverings, duct coverings, duct linings, vapor retarder facings, adhesives, fasteners, tapes, and supplementary materials added to air ducts, plenums, panels, and duct silencers used in duct systems, unless otherwise provided for in 4.3.3.1.1 or 4.3.3.1.2., shall have, in the form in which they are used, a maximum flame spread index of 25 without evidence of continued progressive combustion and a maximum smoke developed index of 50 when tested in accordance with NFPA 255 Standard Method of Test of Surface Burning Characteristics of Building Materials.

b. 4.3.3.1.1 Where these products are to be applied with adhesives, they shall be tested with such adhesives applied, or the adhesives used shall have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when in the final dry state.

c. 4.3.3.1.2 The flame spread and smoke developed index requirements of 4.3.3.1.1 shall not apply to air duct weatherproof coverings where they are located entirely outside of a building, do not penetrate a wall or roof, and do not create an exposure hazard.

d. 4.3.3.2 Closure systems for use with rigid and flexible air ducts tested in accordance with UL 181, Standard for Safety Factory-Made Air Ducts and Air Connectors, shall have been tested, listed, and used in accordance with the conditions of their listings, in accordance with one of the following:

1) UL 181A, Standard for Safety Closure Systems for Use with Rigid Air Ducts and Air Connectors.

2) UL 181B, Standard for Safety Closure Systems for Use with Flexible Air Ducts and Air Connectors.

e. 4.3.3.3 Air duct, panel, and plenum coverings and linings, and pipe insulation and coverings shall not flame, glow, smolder, or smoke when tested in accordance with a similar test for pipe covering, ASTM C 411, Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation, at the temperature to which they are exposed in service.

f. 4.3.3.3.1 In no case shall the test temperature be below 121°C (250°F).

g. 4.3.3.4 Air duct coverings shall not extend through walls or floors that are required to be fire stopped or required to have a fire resistance rating, unless such coverings meet the requirements of 5.4.6.4.

h. 4.3.3.5 Air duct linings shall be interrupted at fire dampers to prevent interference with the operation of devices.

i. 4.3.3.6 Air duct coverings shall not be installed so as to conceal or prevent the use of any service opening.

j. 4.3.10.2.6 Materials exposed to the airflow shall be noncombustible or limited combustible and have a maximum smoke developed index of 50 or comply with the following.

k. 4.3.10.2.6.1 Electrical wires and cables and optical fiber cables shall be listed as noncombustible or limited combustible and have a maximum smoke developed index of 50 or shall be listed as having a maximum peak optical density of 0.5 or less, an average optical density of 0.15 or less, and a maximum flame spread distance of 1.5 m (5 ft) or less when tested in accordance with NFPA 262, Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.

l. 4.3.10.2.6.4 Optical-fiber and communication raceways shall be listed as having a maximum peak optical density of 0.5 or less, an average optical density of 0.15 or less, and a maximum flame spread distance of 1.5 m (5 ft) or less when tested in accordance with UL 2024, Standard for Safety Optical-Fiber Cable Raceway.

m. 4.3.10.2.6.6 Supplementary materials for air distribution systems shall be permitted when complying with the provisions of 4.3.3.

n. 5.4.6.4 Where air ducts pass through walls, floors, or partitions that are required to have a fire resistance rating and where fire dampers are not required, the opening in the construction around the air duct shall be as follows:

1) Not exceeding a 25.4 mm (1 in.) average clearance on all sides

2) Filled solid with an approved material capable of preventing the passage of flame and hot gases sufficient to ignite cotton waste when subjected to the time-temperature fire conditions required for fire barrier penetration as specified in NFPA 251, Standard Methods of Tests of Fire Endurance of Building Construction and Materials.

2. Test methods: ASTM E84, UL 723, or NFPA 255.

3. Specified k factors are at 24 degrees C (75 degrees F) mean temperature unless stated otherwise. Where optional thermal insulation material is used, select thickness to provide thermal conductance no greater than that for the specified material. For pipe, use insulation manufacturer's published heat flow tables. For domestic hot water supply and return, run out insulation and condensation control insulation, no thickness adjustment need be made.

4. All materials shall be compatible and suitable for service temperature, and shall not contribute to corrosion or otherwise attack surface to which applied in either the wet or dry state.

C. Every package or standard container of insulation or accessories delivered to the job site for use must have a manufacturer's stamp or label giving the name of the manufacturer and description of the material.

1.4 SUBMITTALS

A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.

B. Shop Drawings:

1. All information, clearly presented, shall be included to determine compliance with drawings and specifications and ASTM, federal and military specifications.
    a. Insulation materials: Specify each type used and state surface burning characteristics.
    b. Insulation facings and jackets: Each type used. Make it clear that white finish will be furnished for exposed ductwork, casings and equipment.
    c. Insulation accessory materials: Each type used.
    d. Manufacturer's installation and fitting fabrication instructions for flexible unicellular insulation.
    e. Make reference to applicable specification paragraph numbers for coordination.

1.5 STORAGE AND HANDLING OF MATERIAL

Store materials in clean and dry environment, pipe covering jackets shall be clean and unmarred. Place adhesives in original containers. Maintain ambient temperatures and conditions as required by printed instructions of manufacturers of adhesives, mastics and finishing cements.

1.6 APPLICABLE PUBLICATIONS

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

B. Military Specifications (Mil. Spec.):

1. MIL-A-3316C (2)-1987 Adhesives, Fire-Resistant, Thermal Insulation

2. MIL-C-19565C (1)-2016 Coating Compounds, Thermal Insulation, Fire- and Water-Resistant, Vapor-Barrier

C. American Society for Testing and Materials (ASTM):
1. C177-2014 Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission
2. B209-2014 Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
3. C411-2019 Standard test method for Hot-Surface Performance of High-Temperature Thermal Insulation
4. C449-2019 Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement
5. C547-2017 Standard Specification for Mineral Fiber pipe Insulation
6. C553-2015 Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
7. C612-2014 Standard Specification for Mineral Fiber Block and Board Thermal Insulation
8. C1136-2017 Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation
9. E84-2014 Standard Test Method for Surface Burning Characteristics of Building Materials

D. National Fire Protection Association (NFPA):
1. 90A-2018 Standard for the Installation of Air Conditioning and Ventilating Systems
2. 101-2018 Life Safety Code
3. 251-2014 Standard methods of Tests of Fire Endurance of Building Construction Materials
4. 255-2006 Standard Method of tests of Surface Burning Characteristics of Building Materials

PART 2 - PRODUCTS

2.1 MINERAL FIBER OR FIBER GLASS

A. ASTM C612 (Board, Block), Class 1 or 2, density 48 kg/m3 (3 pcf), k = 0.037 (0.26) at 24 degrees C (75 degrees F), external insulation for temperatures up to 204 degrees C (400 degrees F) with foil scrim (FSK) facing.

B. ASTM C553 (Blanket, Flexible) Type I, Class B-3, Density 16 kg/m3 (1 pcf), k = 0.045 (0.31)\plain\rtlch\af1\afs22\alang0\ab\ltrch\f1\fs22\lang0\langnp0\langfe0\langfenp0\b \plain\rtlch\af1\afs22\alang0\ltrch\f1\fs22\lang0\langnp0\langfe0\langfenp0 at 24 degrees C (75 degrees F), for use at temperatures up to 204 degrees C (400 degrees F) with foil scrim (FSK) facing.

C. ASTM C547 (Pipe Fitting Insulation and Preformed Pipe Insulation), Class 1, k = 0.037 (0.26) at 24 degrees C (75 degrees F), for use at temperatures up to 230 degrees C (450 degrees F) with an all service vapor retarder jacket with polyvinyl chloride premolded fitting covering.

2.2 CELLULAR GLASS CLOSED-CELL

A. Comply with Standard ASTM C177, C518, density 120 kg/m3 (7.5 pcf) nominal, k = 0.033 (0.29) at 240 degrees C (75 degrees F).

B. Pipe insulation for use at temperatures up to 200 degrees C (400 degrees F) with all service vapor retarder jacket.

2.3 FLEXIBLE ELASTOMERIC CELLULAR THERMAL

A. ASTM C177, C518, k = 0.039 (0.27) at 24 degrees C (75 degrees F), flame spread not over 25, smoke developed not over 50, for temperatures from minus 4 degrees C (40 degrees F) to 93 degrees C (200 degrees F).

B. No jacket required.

2.4 INSULATION FACINGS AND JACKETS

A. Vapor Retarder, higher strength with low water permeance = 0.02 or less perm rating, Beach puncture 50 units for insulation facing on exposed ductwork, casings and equipment, and for pipe insulation jackets. Facings and jackets shall be all service type (ASJ) or PVDC Vapor Retarder jacketing.

B. ASJ jacket shall be white kraft bonded to 0.025 mm (1 mil) thick aluminum foil, fiberglass reinforced, with pressure sensitive adhesive closure. Comply with ASTM C1136. Beach puncture 50 units, Suitable for painting without sizing. Jackets shall have minimum 40 mm (1-1/2 inch) lap on longitudinal joints and minimum 75 mm (3 inch) butt strip on end joints. Butt strip material shall be same as the jacket. Lap and butt strips shall be self-sealing type with factory-applied pressure sensitive adhesive.

C. Vapor Retarder medium strength with low water vapor permeance of 0.02 or less perm rating), Beach puncture 25 units: Foil-Scrim-Kraft (FSK) or PVDC vapor retarder jacketing type for concealed ductwork and equipment.

D. Field applied vapor barrier jackets shall be provided, in addition to the specified facings and jackets, on all exterior piping and ductwork as well as on interior piping and ductwork conveying fluids below ambient temperature. The vapor barrier jacket shall consist of a multi-layer laminated cladding with a maximum water vapor permeance of 0.001 perms. The minimum puncture resistance shall be 35 cm-kg (30 inch-pounds) for interior locations and 92 cm-kg (80 inch-pounds) for exterior or exposed locations or where the insulation is subject to damage.

E. Factory composite materials may be used provided that they have been tested and certified by the manufacturer.

F. Aluminum Jacket-Piping systems\plain\rtlch\af1\afs22\alang0\ab\ltrch\f1\fs22\lang0\langnp0\langfe0\langfenp0\b :\plain\rtlch\af1\afs22\alang0\ltrch\f1\fs22\lang0\langnp0\langfe0\langfenp0 ASTM B209, 3003 alloy, H-14 temper, 0.6 mm (0.023 inch) minimum thickness with locking longitudinal joints. Jackets for elbows, tees and other fittings shall be factory-fabricated to match shape of fitting and of 0.6 mm (0.024) inch minimum thickness aluminum. Fittings shall be of same construction as straight run jackets but need not be of the same alloy. Factory-fabricated stainless steel bands shall be installed on all circumferential joints. Bands shall be 13 mm (0.5 inch) wide on 450 mm (18 inch) centers. System shall be weatherproof if utilized for outside service.

2.5 PIPE COVERING PROTECTION SADDLES

A. Cold pipe support: Premolded pipe insulation 180 degrees (half-shells) on bottom half of pipe at supports. Material shall be cellular glass or high density Polyisocyanurate insulation of the same thickness as adjacent insulation. Density of Polyisocyanurate insulation shall be a minimum of 48 kg/m3 (3.0 pcf).

B. Warm or hot pipe supports: Premolded pipe insulation (180 degree half-shells) on bottom half of pipe at supports. Material shall be high density Polyisocyanurate (for temperatures up to 149 degrees C [300 degrees F]), cellular glass or calcium silicate. Insulation at supports shall have same thickness as adjacent insulation. Density of Polyisocyanurate insulation shall be a minimum of 48 kg/m3 (3.0 pcf).

2.6 ADHESIVE, MASTIC, CEMENT

A. Mil. Spec. MIL-A-3316, Class 1: Jacket and lap adhesive and protective finish coating for insulation.

B. Mil. Spec. MIL-A-3316, Class 2: Adhesive for laps and for adhering insulation to metal surfaces.

C. Mil. Spec. MIL-A-24179, Type II Class 1: Adhesive for installing flexible unicellular insulation and for laps and general use.

D. Mil. Spec. MIL-C-19565, Type I: Protective finish for outdoor use.

E. Mil. Spec. MIL-C-19565, Type I or Type II: Vapor barrier compound for indoor use.

F. ASTM C449: Mineral fiber hydraulic-setting thermal insulating and finishing cement.

G. Other: Insulation manufacturers' published recommendations.

2.7 MECHANICAL FASTENERS

A. Pins, anchors: Welded pins, or metal or nylon anchors with galvanized steel-coated or fiber washer, or clips. Pin diameter shall be as recommended by the insulation manufacturer.

B. Staples: Outward clinching monel or galvanized steel\plain\rtlch\af1\afs22\alang0\ab\ltrch\f1\fs22\lang0\langnp0\langfe0\langfenp0\b .

C. Wire: 1.3 mm thick (18 gage) soft annealed galvanized or 1.9 mm (14 gage) copper clad steel or nickel copper alloy.

D. Bands: 13 mm (0.5 inch) nominal width, brass, galvanized steel, aluminum or stainless steel.

2.8 REINFORCEMENT AND FINISHES

A. Tape for Flexible Elastomeric Cellular Insulation: As recommended by the insulation manufacturer.

B. Corner beads: 50 mm (2 inch) by 50 mm (2 inch), 0.55 mm thick (26 gage) galvanized steel; or, 25 mm (1 inch) by 25 mm (1 inch), 0.47 mm thick (28 gage) aluminum angle adhered to 50 mm (2 inch) by 50 mm (2 inch) Kraft paper.

2.9 FIRESTOPPING MATERIAL

A. Other than pipe and duct insulation, refer to Section 07 84 00, FIRESTOPPING.

2.10 FLAME AND SMOKE

A. Unless shown otherwise all assembled systems shall meet flame spread 25 and smoke developed 50 rating as developed under ASTM, NFPA and UL standards and specifications. See paragraph 1.3 "Quality Assurance".

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

A. Required pressure tests of duct and piping joints and connections shall be completed and the work approved by the COR for application of insulation. Surface shall be clean and dry with all foreign materials, such as dirt, oil, loose scale and rust removed.

B. Except for specific exceptions, insulate entire specified equipment, piping (pipe, fittings, valves, accessories), and duct systems. Insulate each pipe and duct individually. Do not use scrap pieces of insulation where a full length section will fit.

C. Insulation materials shall be installed in a first class manner with smooth and even surfaces, with jackets and facings drawn tight and smoothly cemented down at all laps. Insulation shall be continuous through all sleeves and openings, except at fire dampers and duct heaters (NFPA 90A). Vapor retarders shall be continuous and uninterrupted throughout systems with operating temperature 16 degrees C (60 degrees F) and below. Lap and seal vapor retarder over ends and exposed edges of insulation. Anchors, supports and other metal projections through insulation on cold surfaces shall be insulated and vapor sealed for a minimum length of 150 mm (6 inches).

D. Install vapor stops at all insulation terminations on either side of valves, pumps and equipment and particularly in straight lengths of pipe insulation.

E. Protect all insulations outside of buildings with aluminum jacket using lock joint or other approved system for a continuous weather tight system. Access doors and other items requiring maintenance or access shall be removable and sealable.

   1. Joints in aluminum jacket systems shall be located on the underside of piping and oriented to prevent water intrusion.

F. HVAC work not to be insulated:

   1. Internally insulated ductwork and air handling units.
   2. Exhaust air ducts and plenums, and ventilation exhaust air shafts.
   3. Equipment: Expansion tanks, flash tanks, hot water pumps, or steam condensate pumps.

4. In hot piping: Unions, flexible connectors, control valves, PRV's, safety valves and discharge vent piping, vacuum breakers, thermostatic vent valves, or steam traps 20 mm (3/4 inch) and smaller. Insulate piping to within approximately 75 mm (3 inches) of uninsulated items.

G. Apply insulation materials subject to the manufacturer's recommended temperature limits. Apply adhesives, mastic and coatings at the manufacturer's recommended minimum coverage.

H. Elbows, flanges and other fittings shall be insulated with the same material as is used on the pipe straight sections. The elbow/fitting insulation shall be field-fabricated, mitered or factory prefabricated to the necessary size and shape to fit on the elbow/fitting. Use of polyurethane spray-foam to fill a PVC elbow jacket is prohibited.

I. Firestop Pipe and Duct insulation:
   1. Provide firestopping insulation at fire and smoke barriers through penetrations. Fire stopping insulation shall be UL listed as defined in Section 07 84 00, FIRESTOPPING.
   2. Pipe and duct penetrations requiring fire stop insulation including, but not limited to the following:
      a. Smoke partitions
      b. Fire partitions
   3. Firestopping shall be red in color.
   4. All locations with firestopping shall be provided with UL listing sticker at each penetration location.

J. Provide vapor barrier jackets over insulation as follows:
   1. All piping and ductwork exposed to outdoor weather.
   2. All interior piping and ducts conveying fluids **exposed to outdoor air (i.e. in attics, ventilated (not air conditioned) spaces, etc.) and below ambient air temperature.**

K. Provide metal jackets over insulation as follows:
   1. All piping and ducts exposed to outdoor weather.

L. Where insulated piping or ductwork penetrates building elements (walls, floor, roof, etc.), insulation shall be continuous through the penetration.

3.2 NSULATION INSTALLATION

A. Mineral Fiber Board:

1. Faced board: Apply board on pins spaced not more than 300 mm (12 inches) on center each way, and not less than 75 mm (3 inches) from each edge of board. In addition to pins, apply insulation bonding adhesive to entire underside of horizontal metal surfaces. Butt insulation edges tightly and seal all joints with laps and butt strips. After applying speed clips cut pins off flush and apply vapor seal patches over clips.
2. Plain board:
   a. Insulation shall be scored, beveled or mitered to provide tight joints and be secured to equipment with bands spaced 225 mm (9 inches) on center for irregular surfaces or with pins and clips on flat surfaces. Use corner beads to protect edges of insulation.
   b. For hot equipment: Stretch 25 mm (1 inch) mesh wire, with edges wire laced together, over insulation and finish with insulating and finishing cement applied in one coat, 6 mm (1/4 inch) thick, trowel led to a smooth finish.
   c. For cold equipment: Apply meshed glass fabric in a tack coat 1.5 to 1.7 square meter per liter (60 to 70 square feet per gallon) of vapor mastic and finish with mastic at 0.3 to 0.4 square meter per liter (12 to 15 square feet per gallon) over the entire fabric surface.
   d. Chilled water pumps: Insulate with removable and replaceable 1 mm thick (20 gage) aluminum or galvanized steel covers lined with insulation. Seal closure joints/flanges of covers with gasket material. Fill void space in enclosure with flexible mineral fiber insulation.

B. Flexible Mineral Fiber Blanket:

1. Adhere insulation to metal with 75 mm (3 inch) wide strips of insulation bonding adhesive at 200 mm (8 inches) on center all around duct. Additionally secure insulation to bottom of ducts exceeding 600 mm (24 inches) in width with pins welded or adhered on 450 mm (18 inch) centers. Secure washers on pins. Butt insulation edges and seal joints with laps and butt strips. Staples may be used to assist in securing insulation. Seal all vapor retarder penetrations with mastic. Sagging duct insulation will not be acceptable. Install firestop duct insulation where required.
2. Supply air ductwork to be insulated includes main and branch ducts from AHU discharge to room supply outlets, and the bodies of ceiling outlets to prevent condensation. Insulate sound attenuator units, coil casings and damper frames. To prevent condensation insulate trapeze type supports and angle iron hangers for flat oval ducts that are in direct contact with metal duct.

C. Molded Mineral Fiber Pipe and Tubing Covering:
1. Fit insulation to pipe or duct, aligning longitudinal joints. Seal longitudinal joint laps and circumferential butt strips by rubbing hard with a nylon sealing tool to assure a positive seal. Staples may be used to assist in securing insulation. Seal all vapor retarder penetrations on cold piping with a generous application of vapor barrier mastic. Provide inserts and install with metal insulation shields at outside pipe supports. Install freeze protection insulation over heating cable.
2. Contractor's options for fitting, flange and valve insulation:
   a. Insulating and finishing cement for sizes less than 100 mm (4 inches) operating at surface temperature of 16 degrees C (61 degrees F) or more.
   b. Factory premolded, one piece PVC covers with mineral fiber, (Form B), inserts. Provide two insert layers for pipe temperatures below 4 degrees C (40 degrees F), or above 121 degrees C (250 degrees F). Secure first layer of insulation with twine. Seal seam edges with vapor barrier mastic and secure with fitting tape.

c. Factory molded, ASTM C547 or field mitered sections, joined with adhesive or wired in place. For hot piping finish with a smoothing coat of finishing cement. For cold fittings, 16 degrees C (60 degrees F) or less, vapor seal with a layer of glass fitting tape imbedded between two 2 mm (1/16 inch) coats of vapor barrier mastic.

d. Fitting tape shall extend over the adjacent pipe insulation and overlap on itself at least 50 mm (2 inches).

3. Nominal thickness in inches specified on the drawings.

D. Cellular Glass Insulation:

1. Pipe and tubing, covering nominal thickness in inches as specified on the drawings.

2. Underground Piping Other than or in lieu of that Specified in Section 23 21 13, HYDRONIC PIPING: Type II, factory jacketed with a 3 mm laminate jacketing consisting of 3000 mm x 3000 mm (10 ft x 10 ft) asphalt impregnated glass fabric, bituminous mastic and outside protective plastic film.

a. Underground piping: Apply insulation with joints tightly butted. Seal longitudinal self-sealing lap. Use field fabricated or factory made fittings. Seal butt joints and fitting with jacketing as recommended by the insulation manufacturer. Use 100 mm (4 inch) wide strips to seal butt joints.

b. Provide expansion chambers for pipe loops, anchors and wall penetrations as recommended by the insulation manufacturer.

c. Underground insulation shall be inspected and approved by the COR as follows:

1) Insulation in place before coating.

2) After coating.

d. Sand bed and backfill: Minimum 75 mm (3 inches) all around insulated pipe or tank, applied after coating has dried.

E. Flexible Elastomeric Cellular Thermal Insulation:

1. Apply insulation and fabricate fittings in accordance with the manufacturer's installation instructions and finish with two coats of weather resistant finish as recommended by the insulation manufacturer.
2. Pipe and tubing insulation:
   a. Use proper size material. Do not stretch or strain insulation.
   b. To avoid undue compression of insulation, provide cork stoppers or wood inserts at supports as recommended by the insulation manufacturer. Insulation shields are specified under Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
   c. Where possible, slip insulation over the pipe or tubing prior to connection, and seal the butt joints with adhesive. Where the slip-on technique is not possible, slit the insulation and apply it to the pipe sealing the seam and joints with contact adhesive. Optional tape sealing, as recommended by the manufacturer, may be employed. Make changes from mineral fiber insulation in a straight run of pipe, not at a fitting. Seal joint with tape.
3. Apply sheet insulation to flat or large curved surfaces with 100 percent adhesive coverage. For fittings and large pipe, apply adhesive to seams only.
4. Pipe insulation: nominal thickness in inches as specified on the drawings.
5. Minimum 20 mm (0.75 inch) thick insulation for pneumatic control lines for a minimum distance of 6 m (20 feet) from discharge side of the refrigerated dryer.
6. Exposed, unlined supply and return ductwork exposed to outdoor weather: 50 mm (2 inch) thick insulation faced with a multi-layer vapor barrier with a water vapor permeance of 0.00 perms.

3.3 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.

B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

- - - END - - -

SECTION 23 08 00
COMMISSIONING OF HVAC SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. The requirements of this Section apply to all sections of Division 23.

B. The commissioning process, which the Contractor is responsible to execute, is defined in Section 01 91 00, GENERAL COMMISSIONING REQUIRMENTS.

1.2 RELATED WORK

A. The requirements of this Section apply to all sections of Division 23.

B. Section 01 00 00, GENERAL REQUIREMENTS.

C. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

D. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

E. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.

F. Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.

G. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

1.3 SUMMARY

A. This Section includes requirements for commissioning the HVAC systems, related subsystems, and related equipment. This Section supplements the general requirements specified in Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

B. Refer to Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS for more details regarding processes and procedures as well as roles and responsibilities for all Commissioning Team members.

1.4 DEFINITIONS

A. Refer to Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS for definitions.

1.5 COMMISSIONED SYSTEMS

A. Commissioning of a system or systems specified in Division 23 is part of the construction process. Documentation and testing of these systems, as well as training of the VA' s Operation and Maintenance personnel in accordance with the requirements of Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS, and of Division 23, is required in cooperation with the VA and the VA's Commissioning Agent.

B. The HVAC systems commissioning will include the following systems:

1. DDC Systems.
2. Data cabinet monitoring systems.
3. Facility fuel oil systems.
4. Fan systems.
5. Energy recovery ventilator systems.
6. Mini-split systems.
7. CRAC systems.
8. VRF systems.
9. Unit heaters.
10. Radon mitigation systems.

1.6 SUBMITTALS

A. The commissioning process requires review of selected Submittals that pertain to the systems to be commissioned. The Commissioning Agent will provide a list of submittals that will be reviewed by the Commissioning Agent. This list will be reviewed and approved by the VA prior to forwarding to the Contractor. Refer to Section 01 33 23, SHOP DRAWINGSS, PRODUCT DATA, AND SAMPLES for further details.

B. The commissioning process requires Submittal review simultaneously with engineering review. Specific submittal requirements related to the commissioning process are specified in Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

1.7 APPLICABLE PUBLICATIONS

A. The following publications form a part of this specification to the extent indicated by the reference thereto. In text the publications are referenced to by the acronym of the organization.

B. Department of Veterans Affairs (VA):

1. PG 18-10 2007 Mission Critical Facilities - DRAFT
2. PG 18-10 2007 Life-Safety Protected Facilities - DRAFT

C. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE):
1. HANDBOOK 2019 HVAC Applications ASHRAE Handbook, Chapter 39, Testing, Adjusting, and Balancing, Chapter 44, HVAC Commissioning and Chapter 49, Sound and Vibration Control
2. HANDBOOK 2017 HVAC Fundamentals ASHRAE Handbook, Chapter 8, Sound and Vibration

D. Associated Air Balance Council (AABC):
1. 7th Edition 2016 AABC National Standards for Total System Balance

E. National Environmental Balancing Bureau (NEBB):
1. 9th Edition 2019 Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems
2. 3rd Edition 2015 Procedural Standards for the Measurement of Sound and Vibration
3. 2rd Edition 2019 Standard for Whole Building Technical Commissioning of New Construction

F. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):
1. 006-2006 HVAC Duct Construction Standard – Metal and Flexible Duct
2. 3rd Edition-2005 HVAC Systems Testing, Adjusting and Balancing

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 CONSTRUCTION INSPECTIONS

A. Commissioning of HVAC systems will require inspection of individual elements of the HVAC systems construction throughout the construction period. The Contractor shall coordinate with the Commissioning Agent in accordance with Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS and the Commissioning plan to schedule HVAC systems inspections as required to support the Commissioning Process.

3.2 PRE-FUNCTIONAL CHECKLISTS

A. The Contractor shall complete Pre-Functional Checklists to verify systems, subsystems, and equipment installation is complete and systems are ready for Systems Functional Performance Testing. The Commissioning Agent will prepare Pre-Functional Checklists to be used to document equipment installation. Refer to Section 13 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT, Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC, and Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC. The Contractor shall complete the checklists. Completed checklists shall be submitted to the VA and to the Commissioning Agent for review. The Commissioning Agent may spot check a sample of completed checklists. If the Commissioning Agent determines that the information provided on the checklist is not accurate, the Commissioning Agent will return the marked-up checklist to the Contractor for correction and resubmission. If the Commissioning Agent determines that a significant number of completed checklists for similar equipment are not accurate, the Commissioning Agent will select a broader sample of checklists for review. If the Commissioning Agent determines that a significant number of the broader sample of checklists is also inaccurate, all the checklists for the type of equipment will be returned to the Contractor for correction and resubmission. Refer to Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS for submittal requirements for Pre-Functional Checklists, Equipment Startup Reports, and other commissioning documents.

3.3 CONTRACTORS TESTS

A. Contractor tests as required by other sections of Division 23 shall be scheduled and documented in accordance with Section 01 00 00, GENERAL REQUIREMENTS. All testing shall be incorporated into the project schedule. Contractor shall provide no less than seven calendar days' notice of testing. The Commissioning Agent will witness selected Contractor tests at the sole discretion of the Commissioning Agent. Contractor tests shall be completed prior to scheduling Systems Functional Performance Testing.

3.4 SYSTEMS FUNCTIONAL PERFORMANCE TESTING

A. The Commissioning Process includes Systems Functional Performance Testing that is intended to test systems functional performance under steady state conditions, to test system reaction to changes in operating conditions, and system performance under emergency conditions. The Commissioning Agent will prepare detailed Systems Functional Performance Test procedures for review and approval by the VA's COR. The Contractor shall review and comment on the tests prior to approval. The Contractor shall provide the required labor, materials, and test equipment identified in the test procedure to perform the tests. The Commissioning Agent will witness and document the testing. The Contractor shall sign the test reports to verify tests were performed.

1. Refer to Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS for additional requirements.

3.5 TRAINING OF VA PERSONNEL

A. Training of the VA operation and maintenance personnel is required in cooperation with the VA's COR and Commissioning Agent. Provide competent, factory authorized personnel to provide instruction to operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. Contractor shall submit training agendas and trainer resumes in accordance with the requirements of Section 01 91 00. The instruction shall be scheduled in coordination with the VA COR after submission and approval of formal training plans.

1. Refer to Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS and Division 23 Sections for additional Contractor training requirements.

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SECTION 23 09 23
DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC

PART 1 – GENERAL

1.1 PROJECT SCOPE

A. Controls work scope for this project shall include the following:
   1. Modify the existing DDC systems as follows:
      a. Remove demolished equipment and systems.
      b. Integrate new equipment and systems.
      c. Update system graphics.
         1) New and modified graphics shall match existing system graphic styles.
   2. Provide new DDC systems as follows:
      a. Install DDC head end software on new virtual server.
      b. Integrate all new equipment and systems provided under this contract.

1.2 DESCRIPTION

A. General Contractor shall provide direct-digital control system(s) as indicated on the project documents, points list(s), interoperability table(s), drawings, and as described in these specifications. Include a complete and working direct-digital control system. Include all engineering, programming, configuration/setup hardware and software, controls and installation materials, installation labor, commissioning and start-up, training, final project documentation and warranty.
   1. The direct-digital control system(s) shall consist of high-speed, peer-to-peer network of DDC controllers, a control system server, all configuration and setup software and hardware devices, and an Engineering Control Center. Provide a remote user using a standard HTML 5 web browser to access the control system graphics and change adjustable setpoints with the proper password.

2. All new building controllers shall be native BACnet. All new controllers, devices, and components shall be listed by BACnet Testing Laboratories. All new workstations, controllers, devices and components shall be accessible using a HTML5 Web browser interface. Browsers shall not require the use of an extension or add on software in order to access aforementioned workstations, controllers, devices, and components.
   a. If used, gateways shall be BTL listed.
   b. If used, gateways shall provide all object properties and read/write services shown on VA-approved interoperability schedules.
3. The work administered by this Section of the technical specifications shall include all labor, materials, special tools, equipment, enclosures, power supplies, software, software licenses, Project specific software configurations and database entries, interfaces, wiring, tubing, installation, labeling, engineering, calibration, documentation, submittals, testing, verification, training services, permits and licenses, transportation, shipping, handling, administration, supervision, management, insurance, Warranty, specified services and any other items required for a complete and fully functional Controls System.
4. The control systems shall be designed such that each mechanical system shall operate under stand-alone mode. The A/E shall designate what each “mechanical systems” is composed of. The contractor administered by this Section of the technical specifications shall provide controllers for each mechanical system. In the event of a network communication failure, or the loss of any other controller, the control system shall continue to operate independently. Failure of the ECC shall have no effect on the field controllers, including those involved with global strategies.
5. The control system shall accommodate a minimum of 5 web-based Users simultaneously, and the access to the system should be limited only by operator password.

B. Some products are furnished but not installed by the contractor administered by this Section of the technical specifications. The contractor administered by this Section of the technical specifications shall formally coordinate in writing and receive from other contractors formal acknowledgements in writing prior to submission the installation of the products. These products include but are not limited to the following:
   1. Control valves.
   2. Flow switches.
   3. Flow meters.
   4. Sensor wells and sockets in piping.
   5. Terminal unit controllers.

C. Some products are installed but not furnished by the contractor administered by this Section of the technical specifications. The contractor administered by this Section of the technical specifications shall formally coordinate in writing and receive from other contractors formal acknowledgements in writing prior to submission the procurement of the products. These products include but are not limited to the following:
   1. Refrigerant leak detection systems.
   2. Factory-furnished accessory thermostats and sensors furnished with the following equipment:
      a. Mini-split air conditioning systems

D. Some products are not provided by, but are nevertheless integrated with the work executed by, the contractor administered by this Section of the technical specifications. The contractor administered by this Section of the technical specifications shall formally coordinate in writing and receive from other contractors formal acknowledgements in writing prior to submission the particulars of the products. These products include, but are not limited to, the following:
   1. Fire alarm systems. If zoned fire alarm is required by the project- specific requirements, this interface shall require multiple relays, which are provided and installed by the fire alarm system contractor, to be monitored.

2. Unitary HVAC equipment (including but not limited to rooftop air conditioning units, split systems, variable refrigerant flow systems, mini-split air conditioning systems, computer room air handling systems, and packaged unitary heat recovery units) controls.
3. Variable frequency drives. These controls, if not native BACnet, will require a Gateway.
4. Heat trace systems. All heat trace systems shall be monitored for operational status and shall provide status alarm if not operational during freezing conditions.
   a. Relays, current transformers, and other devices necessary for monitoring of heat trace systems by DDC shall be provided by DDC contractor.
   b. Each heat trace system shall be separately monitored and alarmed.
5. The following systems have limited control (as individually noted below) from the ECC:
   a. Emergency generators: Status and alarms.
   b. Facility fuel monitoring systems: Fuel levels and alarms.
   c. Liquid leak detection: Status and alarms.
   d. Refrigerant leak detection: Status and alarms.

E. Responsibility Table:

Work/Item/System	Furnish	Install	Low Voltage Wiring	Line Power
Control system low voltage and communication wiring	23 09 23	23 09 23	23 09 23	N/A
Terminal units	23	23	N/A	26
Controllers for terminal units	23 09 23	23	23 09 23	16
LAN conduits and raceway	23 09 23	23 09 23	N/A	N/A
Automatic dampers (not furnished with equipment)	23 09 23	23	N/A	N/A

Automatic damper actuators	23 09 23	23 09 23	23 09 23	23 09 23
Manual valves	23	23	N/A	N/A
Automatic valves	23 09 23	23	23 09 23	23 09 23
Pipe insertion devices and taps, flow and pressure stations.	23	23	N/A	N/A
Thermowells	23 09 23	23	N/A	N/A
Current Switches	23 09 23	23 09 23	23 09 23	N/A
Control Relays	23 09 23	23 09 23	23 09 23	N/A
Power distribution system monitoring interfaces	23 09 23	23 09 23	23 09 23	26
Interface with chiller/boiler controls	23 09 23	23 09 23	23 09 23	26
Chiller/boiler controls interface with control system	23	23	23 09 23	26
All control system nodes, equipment, housings, enclosures and panels.	23 09 23	23 09 23	23 09 23	26
Smoke detectors	28 31 00	28 31 00	28 31 00	28 31 00
Fire/Smoke Dampers	23	23	28 31 00	28 31 00
Smoke Dampers	23	23	28 31 00	28 31 00
Fire Dampers	23	23	N/A	N/A
Chiller/starter interlock wiring	N/A	N/A	26	26
Chiller Flow Switches	23	23	23	N/A
Boiler interlock wiring	23	23	23	26
Boiler Flow Switches	23	23	23	N/A

Water treatment system	23	23	23	26
VFDs	23	26	23 09 23	26
Refrigerant monitors	23	23 09 23	23 09 23	26
Laboratory Environmental Controls	23 09 23	23 09 23	23 09 23	26
Fume hood controls	23 09 23	23 09 23	23 09 23	26
Medical gas panels	23	23	26	26
Laboratory Air Valves	23	23	23 09 23	N/A
Computer Room A/C Unit field-mounted controls	23	23	26	26
Control system interface with CRU A/C controls	23 09 23	23 09 23	23 09 23	26
CRU A/C unit controls interface with control system	23	23 09 23	23 09 23	26
Fire Alarm shutdown relay interlock wiring	28	28	28	26
Control system monitoring of fire alarm smoke control relay	28	28	23 09 23	28
Fire-fighter’s smoke control station (FSCS	28	28	28	28
Fan Coil Unit controls (not furnished with equipment)	23 09 23	23 09 23	23 09 23	26
Unit Heater controls (not furnished with equipment)	23 09 23	23 09 23	23 09 23	26
Packaged RTU space-mounted controls (not	23 09 23	23 09 23	23 09 23	26

furnished with equipment)				
Packaged RTU unit-mounted controls (not furnished with equipment)	23 09 23	23 09 23	23 09 23	26
Cooling Tower Vibration Switches	23	23	23 09 23	23 09 23
Cooling Tower Level Control Devices	23	23	23 09 23	23 09 23
Cooling Tower makeup water control devices	23	23	23 09 23	23 09 23
Starters, HOA switches	23	23	N/A	26
Steam Trap Monitoring in Boiler Plant	23 21 11	23 21 11	26	26
Steam Trap Monitoring not in Boiler Plant	23 22 13	23 22 13	26	26

F. Existing DDC system information:

1. The contractor administered by this Section of the technical specifications shall observe the capabilities, communication network, services, spare capacity of the existing control system and its ECC prior to beginning work.
2. Manufacturer: Mixture of Honeywell XL500 & Schneider Electric systems.
3. DDC Communications: DDC communications in each building run on the main building LAN system administered by the VA IT department.
4. Leave existing direct-digital control system in place.
   a. Remove demolished equipment and systems from existing DDC systems, including updating associated graphics.

G. New DDC Systems

1. Provide a new ASHRAE Standard 135, BACnet/IP DDC system including virtual ECC, communications network, controllers, sensors, and actuating devices.
2. New controllers and BACNet devices shall be Native BACNet type.
3. ECC shall be virtual, installed on virtual server located in MCR. The contractor administered by this Section of the technical specifications shall coordinate with VA for virtual server installation and configuration on VA network.
4. New DDC system shall run on the main building LAN system administered by the VA IT department.
5. The contractor administered by this Section of the technical specifications shall provide all necessary investigation and site-specific programming to execute the interoperability schedules.
6. Integrate all new equipment and systems installed under this contract.

H. The direct-digital control system shall start and stop equipment, move (position) damper actuators and valve actuators, and vary speed of equipment to execute the mission of the control system. Use electricity as the motive force for all damper and valve actuators.

1.3 RELATED WORK

A. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
B. Section 23 08 00, COMMISSIONING FOR HVAC.
C. Section 23 10 00, FACILITY FUEL SYSTEMS.
D. Section 23 81 00, DECENTRALIZED UNITARY HVAC EQUIPMENT.
E. Section 23 81 23, COMPUTER-ROOM AIR-CONDITIONERS.
F. Section 23 81 45, VARIABLE REFRIGERANT FLOW SYSTEMS.
G. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
H. Section 26 05 19, L0W-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW).
I. Section 26 05 26, CROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.
J. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS.
K. Section 26 27 26, WIRING DEVICES.
L. Section 27 05 11, REQUIREMENTS FOR COMMUNICATIONS INSTALLATIONS.
M. Section 27 05 26, GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS.

N. Section 27 05 33, CONDUITS AND BACKBOXES FOR COMMUNICATIONS SYSTEMS.
O. Section 27 08 00, COMMISSIONING FOR COMMUNICATIONS SYSTEMS.
P. Section 27 10 00, STRUCTURED CABLING.
Q. Section 27 11 16, COMMUNICATIONS CABINETS, RACKS, FRAMES, AND ENCLOSURES.
R. Section 27 13 13, COMMUNICATIONS COPPER BACKBONE CABLING.
S. Section 27 13 23, COMMUNICATIONS OPTICAL FIBER BACKBONE CABLING.
T. Section 27 15 13, COMMUNICATIONS COPPER HORIZONTAL CABLING.
U. Section 27 16 19, COMMUNICATIONS PATCH CORDS, STATION CORDS, AND CROSS CONNECT WIRE.
V. Section 28 31 00, FIRE DETECTION AND ALARM.

1.4 DEFINITION

A. Algorithm: A logical procedure for solving a recurrent mathematical problem; A prescribed set of well-defined rules or processes for the solution of a problem in a finite number of steps.
B. Analog: A continuously varying signal value (e.g., temperature, current, velocity etc.
C. BACnet: A Data Communication Protocol for Building Automation and Control Networks -as defined by ANSI/ASHRAE Standard 135. This communications protocol allows diverse building automation devices to communicate data and services over a network.
D. BACnet/IP: Annex J of Standard 135. It defines and allows for using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP sub-networks that share the same BACnet network number.
E. BACnet Internetwork: Two or more BACnet networks connected with routers. The two networks may use different LAN technologies.
F. BACnet Network: One or more BACnet segments that have the same network address and are interconnected by bridges at the physical and data link layers.
G. BACnet Segment: One or more physical segments of BACnet devices on a BACnet network, connected at the physical layer by repeaters.
H. BACnet Broadcast Management Device (BBMD): A communications device which broadcasts BACnet messages to all BACnet/IP devices and other BBMDs connected to the same BACnet/IP network.

I. BACnet Interoperability Building Blocks (BIBBs): BACnet Interoperability Building Blocks (BIBBs) are collections of one or more BACnet services. These are prescribed in terms of an "A" and a "B" device. Both of these devices are nodes on a BACnet internetwork.

J. BACnet Testing Laboratories (BTL). The organization responsible for testing products for compliance with the BACnet standard, operated under the direction of BACnet International.

K. Baud: It is a signal change in a communication link. One signal change can represent one or more bits of information depending on type of transmission scheme. Simple peripheral communication is normally one bit per Baud. (e.g., Baud rate = 78,000 Baud/sec is 78,000 bits/sec, if one signal change = 1 bit).

L. Binary: A two-state system where a high signal level represents an "ON" condition and an "OFF" condition is represented by a low signal level.

M. BMP or bmp: Suffix, computerized image file, used after the period in a DOS-based computer file to show that the file is an image stored as a series of pixels.

N. Bus Topology: A network topology that physically interconnects workstations and network devices in parallel on a network segment.

O. Control Unit (CU): Generic term for any controlling unit, stand-alone, microprocessor based, digital controller residing on secondary LAN or Primary LAN, used for local controls or global controls

P. Deadband: A temperature range over which no heating or cooling is supplied, i.e., 22-25 degrees C (72-78 degrees F), as opposed to a single point change over or overlap).

Q. Device: a control system component that contains a BACnet Device Object and uses BACnet to communicate with other devices.

R. Device Object: 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.

S. Device Profile: A specific group of services describing BACnet capabilities of a device, as defined in ASHRAE Standard 135-2008, Annex L. Standard device profiles include BACnet Operator Workstations (B- OWS), 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). Each device used in new construction is required to have a PICS statement listing which service and BIBBs are supported by the device.

T. Diagnostic Program: A software test program, which is used to detect and report system or peripheral malfunctions and failures. Generally, this system is performed at the initial startup of the system.

U. Direct Digital Control (DDC): Microprocessor based control including Analog/Digital conversion and program logic. A control loop or subsystem in which digital and analog information is received and processed by a microprocessor, and digital control signals are generated based on control algorithms and transmitted to field devices in order to achieve a set of predefined conditions.

V. Distributed Control System: A system in which the processing of system data is decentralized and control decisions can and are made at the subsystem level. System operational programs and information are provided to the remote subsystems and status is reported back to the Engineering Control Center. Upon the loss of communication with the Engineering Control center, the subsystems shall be capable of operating in a stand-alone mode using the last best available data.

W. Download: The electronic transfer of programs and data files from a central computer or operation workstation with secondary memory devices to remote computers in a network (distributed) system.

X. DXF: An AutoCAD 2-D graphics file format. Many CAD systems import and export the DXF format for graphics interchange.

Y. Electrical Control: A control circuit that operates on line or low voltage and uses a mechanical means, such as a temperature sensitive bimetal or bellows, to perform control functions, such as actuating a switch or positioning a potentiometer.

Z. Electronic Control: A control circuit that operates on low voltage and uses a solid-state components to amplify input signals and perform control functions, such as operating a relay or providing an output signal to position an actuator.

AA. Engineering Control Center (ECC): The centralized control point for the intelligent control network. The ECC comprises of personal computer and connected devices to form a single workstation.

BB. Ethernet: A trademark for a system for exchanging messages between computers on a local area network using coaxial, fiber optic, or twisted-pair cables.

CC. Firmware: Firmware is software programmed into read only memory (ROM) chips. Software may not be changed without physically altering the chip.

DD. Gateway: Communication hardware connecting two or more different protocols. It translates one protocol into equivalent concepts for the other protocol. In BACnet applications, a gateway has BACnet on one side and non-BACnet (usually proprietary) protocols on the other side.

EE. GIF: Abbreviation of Graphic interchange format.

FF. Graphic Program (GP): Program used to produce images of air handler systems, fans, chillers, pumps, and building spaces. These images can be animated and/or color-coded to indicate operation of the equipment.

GG. Graphic Sequence of Operation: It is a graphical representation of the sequence of operation, showing all inputs and output logical blocks.

HH. I/O Unit: The section of a digital control system through which information is received and transmitted. I/O refers to analog input (AI, digital input (DI), analog output (AO) and digital output (DO). Analog signals are continuous and represent temperature, pressure, flow rate etc, whereas digital signals convert electronic signals to digital pulses (values), represent motor status, filter status, on-off equipment etc.

II. I/P: a method for conveying and routing packets of information over LAN paths. User Datagram Protocol (UDP) conveys information to “sockets” without confirmation of receipt. Transmission Control Protocol (TCP) establishes "sessions", which have end-to-end confirmation and guaranteed sequence of delivery.

JJ. JACE: Java Application Control Engine.

KK. JPEG: A standardized image compression mechanism stands for Joint Photographic Experts Group, the original name of the committee that wrote the standard.

LL. Local Area Network (LAN): A communication bus that interconnects operator workstation and digital controllers for peer-to-peer communications, sharing resources and exchanging information.

MM. Network Repeater: A device that receives data packet from one network and rebroadcasts to another network. No routing information is added to the protocol.

NN. MS/TP: Master-slave/token-passing (ISO/IEC 8802, Part 3).It uses twisted-pair wiring for relatively low speed and low cost communication.

OO. Native BACnet Device: A device that uses BACnet as its primary method of communication with other BACnet devices without intermediary gateways. A system that uses native BACnet devices at all levels is a native BACnet system.

PP. Network Number: A site-specific number assigned to each network segment to identify for routing. This network number must be unique throughout the BACnet internetwork.

QQ. Object: The concept of organizing BACnet information into standard components with various associated properties. Examples include analog input objects and binary output objects.

RR. Object Identifier: An object property used to identify the object, including object type and instance. Object Identifiers must be unique within a device.

SS. Object Properties: 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.

TT. Operating system (OS): Software, which controls the execution of computer application programs.

UU. PCX: File type for an image file. When photographs are scanned onto a personal computer they can be saved as PCX files and viewed or changed by a special application program as Photo Shop.

VV. Peripheral: Different components that make the control system function as one unit. Peripherals include monitor, printer, and I/O unit.

WW. Peer-to-Peer: A networking architecture that treats all network stations as equal partners- any device can initiate and respond to communication with other devices.

XX. PICS: Protocol Implementation Conformance Statement, describing the BACnet capabilities of a device. All BACnet devices have published PICS.

YY. PID: Proportional, integral, and derivative control, used to control modulating equipment to maintain a setpoint.

ZZ. Repeater: A network component that connects two or more physical segments at the physical layer.

AAA. Router: a component that joins together two or more networks using different LAN technologies. Examples include joining a BACnet Ethernet LAN to a BACnet MS/TP LAN.

BBB. Sensors: devices measuring state points or flows, which are then transmitted back to the DDC system.

CCC. Thermostats : devices measuring temperatures, which are used in control of standalone or unitary systems and equipment not attached to the DDC system.

1.5 QUALITY ASSURANCE

A. Criteria:

1. Single Source Responsibility of subcontractor: Either the DDC Contractor or the System Integrator shall obtain hardware and software supplied under this Section and delegate the responsibility to a single source controls installation subcontractor. The Integration subcontractor shall be responsible for the complete design, installation, integration, and commissioning of the system. The controls subcontractor shall be in the business of design, installation and service of such building automation control systems similar in size and complexity.

2. Equipment and Materials: Equipment and materials shall be cataloged products of manufacturers regularly engaged in production and installation of HVAC control systems. Products shall be manufacturer’s latest standard design and have been tested and proven in actual use.
3. The controls subcontractor shall provide a list of no less than five similar projects which have building control systems as specified in this Section. These projects must be on-line and functional such that the Department of Veterans Affairs (VA) representative could observe the control systems in full operation.
4. The controls subcontractor shall have an in-place facility within 250 miles with technical staff, spare parts inventory for the next five years, and necessary test and diagnostic equipment to support the control systems.
5. The controls subcontractor shall have minimum of three years' experience in design and installation of building automation systems similar in performance to those specified in this Section. Provide evidence of experience by submitting resumes of the project manager, the local branch manager, project engineer, the application engineering staff, and the electronic technicians who would be involved with the supervision, the engineering, and the installation of the control systems. Training and experience of these personnel shall not be less than three years. Failure to disclose this information will be a ground for disqualification of the supplier.
6. Provide a competent and experienced Project Manager employed by the Controls Contractor. The Project Manager shall be supported as necessary by other Contractor employees in order to provide professional engineering, technical and management service for the work. The Project Manager shall attend scheduled Project Meetings as required and shall be empowered to make technical, scheduling and related decisions on behalf of the Controls Contractor.

B. Codes and Standards:
   1. All work shall conform to the applicable Codes and Standards.

2. Electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Governing Radio Frequency Electromagnetic Interference, and be so labeled.

1.6 PERFORMANCE

A. The system shall conform to the following:

1. Graphic Display: The system shall display up to four (4) graphics on a single screen with a minimum of twenty (20) dynamic points per graphic. All current data shall be displayed within ten (10) seconds of the request.
2. Graphic Refresh: The system shall update all dynamic points with current data within eight (8) seconds. Data refresh shall be automatic, without operator intervention.
3. Object Command: The maximum time between the command of a binary object by the operator and the reaction by the device shall be two(2) seconds. Analog objects shall start to adjust within two (2) seconds.
4. Object Scan: All changes of state and change of analog values shall be transmitted over the high-speed network such that any data used or displayed at a controller or work-station will be current, within the prior six (6) seconds.
5. Alarm Response Time: The maximum time from when an object goes into alarm to when it is annunciated at the workstation shall not exceed (10) seconds.
6. Program Execution Frequency: Custom and standard applications shall be capable of running as often as once every (5) seconds. The Contractor shall be responsible for selecting execution times consistent with the mechanical process under control.
7. Multiple Alarm Annunciations: All workstations on the network shall receive alarms within five (5) seconds of each other.
8. Performance: Programmable Controllers shall be able to execute DDC PID control loops at a selectable frequency from at least once every one (1) second. The controller shall scan and update the process value and output generated by this calculation at this same frequency.

9. Reporting Accuracy: Listed below are minimum acceptable reporting end-to-end accuracies for all values reported by the specified system:

Measured Variable	**Reported Accuracy**
Space temperature	±0.5°C (±1°F)
Ducted air temperature	±0.5°C [±1°F]
Outdoor air temperature	±1.0°C [±2°F]
Dew Point	±1.5°C [±3°F]
Water temperature	±0.5°C [±1°F]
Relative humidity	±2% RH
Water flow	±1% of reading
Air flow (terminal)	±10% of reading
Air flow (measuring stations)	±5% of reading
Carbon Monoxide (CO)	±5% of reading
Carbon Dioxide (CO_2)	±50 ppm
Air pressure (ducts)	±25 Pa [±0.1"w.c.]
Air pressure (space)	±0.3 Pa [±0.001"w.c.]
Water pressure	±2% of full scale (for both absolute and differential pressure)
Electrical Power	±0.5% of reading

10. Control stability and accuracy: Control sequences shall maintain measured variable at setpoint within the following tolerances:

Controlled Variable	**Control Accuracy**	**Range of Medium**
Air Pressure	±50 Pa (±0.2 in. w.g.)	0-1.5 kPa (0-6 in. w.g.)
Air Pressure	±3 Pa (±0.01 in. w.g.)	-25 to 25 Pa (-0.1 to 0.1 in. w.g.)
Airflow	±10% of full scale	
Space Temperature	±1.0°C (±2.0°F)	
Duct Temperature	±1.5°C (±3°F)	
Humidity	±5% RH	
Fluid Pressure	±10 kPa (±1.5 psi)	0-1 MPa (1-150 psi)
Fluid Pressure	±250 Pa (±1.0 in. w.g.)	0-12.5 kPa (0-50 in. w.g.) differential

11. Extent of direct digital control: The control design shall allow for at least the following points:
    a. Points indicated on the points list(s) on the drawings.
    b. Points required to accomplish the functionality indicated in the contract documents.
    c. Points required to fully integrate the factory controls for unitary equipment into the DDC system for monitoring, control, setpoints, and alarms.
    d. Points required to meet applicable Code and local requirements.

1.7 WARRANTY

A. Labor and materials for control systems shall be warranted for a period as specified under Warranty in FAR clause 52.246-21.

B. Control system failures during the warranty period shall be adjusted, repaired, or replaced at no cost or reduction in service to the owner. The system includes all computer equipment, transmission equipment, and all sensors and control devices.

C. The on-line support service shall allow the Controls supplier to dial out over telephone lines to or connect via (through password-limited access) VPN through the internet monitor and control the facility's building automation system. This remote connection to the facility shall be within 2 hours of the time that the problem is reported. This coverage shall include normal business hours, after business hours, weekend and holidays. If the problem cannot be resolved with on-line support services, the Controls supplier shall dispatch the qualified personnel to the job site to resolve the problem within 24 hours after the problem is reported.

D. Controls and Instrumentation subcontractor shall be responsible for temporary operations and maintenance of the control systems during the construction period until final commissioning, training of facility operators and acceptance of the project by VA.

E. The Controls supplier shall dispatch the qualified personnel to the job site to resolve the problem within 24 hours after the problem is reported.

F. Contractor shall provide a cellular device and service to allow remote connection to the new DDC systems at the facility during the warranty period.
   1. Contractor shall coordinate with the COR to determine cellular service provider requirements, should the VA opt to maintain the cellular system after the warranty period.
   2. Contractor shall provide all components (including but not limited to SIM card(s) for the cellular system.
   3. Contractor may provide independent cellular system for each building in work scope or single cellular system located in new MCR with access to all new DDC systems.
   4. All remote access shall be encrypted and secured by password.

1.8 SUBMITTALS

A. Submit shop drawings in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC", with applicable paragraph identification.

C. Manufacturer's literature and data including the following:
   1. A wiring diagram for each type of input device and output device including DDC controllers, modems, repeaters, etc. Diagram shall show how the device is wired and powered, showing typical connections at the digital controllers and each power supply, as well as the device itself. Show for all field connected devices, including but not limited to, control relays, motor starters, electric or electronic actuators, and temperature pressure, flow and humidity sensors and transmitters.
   2. A diagram of each terminal strip, including digital controller terminal strips, terminal strip location, termination numbers and the associated point names.
   3. Control dampers and control valves schedule, including the size and pressure drop.

4. Catalog cut sheets of all equipment used. This includes, but is not limited to software (by manufacturer and by third parties), DDC controllers, panels, peripherals, airflow measuring stations and associated components, and auxiliary control devices such as sensors, actuators, and control dampers. When manufacturer's cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted. Each submitted piece of literature and drawings should clearly reference the specification and/or drawings that it supposed to represent.
5. Sequence of operations for each system and the associated control diagrams. Equipment and control labels shall correspond to those shown on the drawings.
6. Color prints of proposed graphics with a list of points for display.
7. Furnish a BACnet Protocol Implementation Conformance Statement (PICS) for each BACnet-compliant device.
8. Schematic wiring diagrams for all control, communication and power wiring. Provide a schematic drawing of the central system installation. Label all cables and ports with computer manufacturers' model numbers and functions. Show all interface wiring to the control system.
9. An instrumentation list for each controlled system. Each element of the controlled system shall be listed in table format. The table shall show element name, type of device, manufacturer, model number, and product data sheet number.
10. Riser diagrams of wiring between central control unit (CCU) and all control panels.
11. Plan drawings showing routing of LAN and locations of control panels, controllers, routers, gateways, ECC, and larger controlled devices.
12. Construction details for all installed conduit, cabling, raceway, cabinets, and similar. Construction details of all penetrations and their protection.

13. Quantities of submitted items may be reviewed but it is the responsibility of the contractor administered by this Section of the technical specifications to provide sufficient quantities for a complete and working system.

D. Product Certificates: Compliance with Article, QUALITY ASSURANCE.

E. Validation Test Plan: Along with manufacturer's literature, product certificates, wiring and functional diagrams, and sequence of operations, submit for review and approval a Validation Test Plan which is specific to the work of this project and which references the specific controls component nomenclatures found in the control contractor's wiring and functional diagrams and the specific sequences of controls for this project and which describes how the contractor will implement the controls system validation and demonstration as specified in paragraph 3.2 SYSTEM VALIDATION AND DEMONSTRATION found in this section.

F. Licenses: Provide licenses for all software residing on and used by the Controls Systems, ECC, and portable OWS and transfer these licenses to the Owner prior to completion.

G. Software Tools: Provide copy of all required software tools, access codes, graphics libraries, and hardware, etc., required to work on DDC software, to the VA at project closeout.

H. As Built Control Drawings:

1. Submit in accordance with Article, INSTRUCTIONS, in Specification Section 01 00 00, GENERAL REQUIREMENTS.
2. Furnish three (3) copies of as-built drawings for each control system. The documents shall be submitted for approval prior to final completion.
3. Furnish one (1) stick set of applicable control system prints for each mechanical system for wall mounting. The documents shall be submitted for approval prior to final completion.
4. Furnish one (1) CD-ROM in CAD DWG and/or .DXF format for the drawings noted in subparagraphs above.

I. Operation and Maintenance (O/M) Manuals):

1. Submit in accordance with Article, INSTRUCTIONS, in Specification Section 01 00 00, GENERAL REQUIREMENTS.
2. Include the following documentation:
   a. General description and specifications for all components, including logging on/off, alarm handling, producing trend reports, overriding computer control, and changing set points and other variables.
   b. Detailed illustrations of all the control systems specified for ease of maintenance and repair/replacement procedures, and complete calibration procedures.
   c. One copy of the final version of all software provided including operating systems, programming language, operator workstation software, and graphics software.
   d. Complete troubleshooting procedures and guidelines for all systems.
   e. Complete operating instructions for all systems.
   f. Recommended preventive maintenance procedures for all system components including a schedule of tasks for inspection, cleaning and calibration. Provide a list of recommended spare parts needed to minimize downtime.
   g. Training Manuals: Submit the course outline and training material to the Owner for approval three (3) weeks prior to the training to VA facility personnel. These persons will be responsible for maintaining and the operation of the control systems, including programming. The Owner reserves the right to modify any or all of the course outline and training material.
   h. Licenses, guaranty, and other pertaining documents for all equipment and systems.

J. Submit Performance Report to COR prior to final inspection.

1.9 INSTRUCTIONS

A. Instructions to VA operations personnel:
   1. Perform in accordance with Article, INSTRUCTIONS, in Specification Section 01 00 00, GENERAL REQUIREMENTS, and as noted below.

2. First Phase: Formal instructions to the VA facilities personnel for a total of 8 hours, given in multiple training sessions (each no longer than 4 hours in length), conducted sometime between the completed installation and prior to the functional testing period of the control system, at a time mutually agreeable to the Contractor and the VA.
3. Second Phase: This phase of training shall comprise of on the job training during startup, checkout period, and functional test period. VA facilities personnel will work with the Contractor's installation and test personnel on a daily basis during startup and checkout period. During the functional testing period, controls subcontractor will provide 8 hours of instructions, given in multiple training sessions (each no longer than 4 hours in length), to the VA facilities personnel.
4. The O/M Manuals shall contain approved submittals as outlined in Article 1.07, SUBMITTALS. The Controls subcontractor will review the manual contents with VA facilities personnel during second phase of training.
5. Training shall be given by direct employees of the controls system subcontractor.

1.10 PROJECT CONDITIONS (ENVIRONMENTAL CONDITIONS OF OPERATION)

A. The ECC and peripheral devices and system support equipment shall be designed to operate in ambient condition of 20 to 35°C (65 to 90°F) at a relative humidity of 20 to 80% non-condensing.
B. The CUs used outdoors shall be mounted in NEMA 4 waterproof enclosures, and shall be rated for operation at -40 to 65°C (-40 to 150°F).
C. All electronic equipment shall operate properly with power fluctuations of plus 10 percent to minus 15 percent of nominal supply voltage.
D. Sensors and controlling devices shall be designed to operate in the environment, which they are sensing or controlling.

1.11 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Where conflicts occur these specifications and the VHA standards will govern.

B. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):
   1. Standard 135-2020 BACnet - A Data Communication Protocol for Building Automation and Control Networks.
   2. Standard 147-2019 Reducing the Release of Halogenated Refrigerants from Refrigerating and Air-Conditioning Equipment and Systems.

C. American Society of Mechanical Engineers (ASME):
   1. B16.18-01 Cast Copper Alloy Solder Joint Pressure Fittings.
   2. B16.22-01 Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.

D. American Society of Testing Materials (ASTM):
   1. B32-08 Standard Specification for Solder Metal.
   2. B88-09 Standard Specifications for Seamless Copper Water Tube.
   3. B88M-09 Standard Specification for Seamless Copper Water Tube (Metric).
   4. B280-08 Standard Specification for Seamless Copper Tube for Air-Conditioning and Refrigeration Field Service.
   5. D2737-03 Standard Specification for Polyethylene (PE) Plastic Tubing.

E. Federal Communication Commission (FCC):
   1. Rules and Regulations Title 47 Chapter 1-2014 Part 15: Radio Frequency Devices.

F. Institute of Electrical and Electronic Engineers (IEEE):
   1. 802.3-2018 Standard for Ethernet.

G. National Fire Protection Association (NFPA):
   1. 70-2023 National Electric Code.
   2. 90A-2021 Standard for Installation of Air-Conditioning and Ventilation Systems.

H. Underwriter Laboratories Inc (UL):

1. Tests for Flammability of Plastic Materials for Parts and Devices and Appliances.
2. 294-10 Access Control System Units.
3. 486A/486B-10 Wire Connectors.
4. 555S-11 Standard for Smoke Dampers.
5. 916-10 Energy Management Equipment.
6. 1076-10 Proprietary Burglar Alarm Units and Systems.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Use new products that the manufacturer is currently manufacturing and that have been installed in a minimum of 25 installations. Spare parts shall be available for at least five years after completion of this contract.

2.2 CONTROLS SYSTEM ARCHITECTURE

A. General

1. The Controls Systems shall consist of multiple Nodes and associated equipment connected by industry standard digital and communication network arrangements.
2. The ECC, building controllers and principal communications network equipment shall be standard products of recognized major manufacturers available through normal PC and computer vendor channels - not "Clones" assembled by a third-party subcontractor.
3. The networks shall, at minimum, comprise, as necessary, the following:
   a. A fixed ECC.
   b. A portable operator's terminal.
   c. Network computer processing, data storage and BACNet-compliant communication equipment including Servers and digital data processors.
   d. BACNet-compliant routers, bridges, switches, hubs, modems, gateways, interfaces and similar communication equipment.
   e. Active processing BACNet-compliant building controllers connected to other BACNet-compliant controllers together with their power supplies and associated equipment.

f. Addressable elements, sensors, transducers and end devices.
g. Third-party equipment interfaces and gateways as described and required by the Contract Documents.
h. Other components required for a complete and working Control Systems as specified.

B. The Specifications for the individual elements and component subsystems shall be minimum requirements and shall be augmented as necessary by the Contractor to achieve both compliance with all applicable codes, standards and to meet all requirements of the Contract Documents.

C. Network Architecture
1. The Controls communication network shall utilize BACnet communications protocol operating over a standard Ethernet LAN and operate at a minimum speed of 100 Mb/sec.
2. The networks shall utilize only copper and optical fiber communication media as appropriate and shall comply with applicable codes, ordinances and regulations.
3. All necessary ISDN lines and Internet Service Provider services and connections will be provided by the VA.

D. Third Party Interfaces:
1. The contractor administered by this Section of the technical specifications shall include necessary hardware, equipment, software and programming to allow data communications between the controls systems and building systems supplied by other trades.
2. Other manufacturers and contractors supplying other associated systems and equipment shall provide their necessary hardware, software and start-up at their cost and shall cooperate fully with the contractor administered by this Section of the technical specifications in a timely manner and at their cost to ensure complete functional integration.

E. Servers:
1. Provide data storage server(s) to archive historical data including trends, alarm and event histories and transaction logs.

2. Equip these server(s) with the same software tool set that is located in the BACnet building controllers for system configuration and custom logic definition and color graphic configuration.
3. Access to all information on the data storage server(s) shall be through the same browser functionality used to access individual nodes. When logged onto a server the operator will be able to also interact with any other controller on the control system as required for the functional operation of the controls systems. The contractor administered by this Section of the technical specifications shall provide all necessary digital processor programmable data storage server(s).
4. These server(s) shall be utilized for controls systems application configuration, for archiving, reporting and trending of data, for operator transaction archiving and reporting, for network information management, for alarm annunciation, for operator interface tasks, for controls application management and similar.
5. These server(s) shall utilize IT industry standard data base platforms which utilize a database declarative language designed for managing data in relational database management systems (RDBMS) such as SQL.

2.3 COMMUNICATION

A. Control products, communication media, connectors, repeaters, hubs, and routers shall comprise a BACnet internetwork. Controller and operator interface communication shall conform to ANSI/ASHRAE Standard 135.
   1. The Data link/physical layer protocol between the ECC and all B-BC’s (for communication) acceptable to the VA throughout its facilities is Ethernet (ISO 8802-3) and BACnet/IP.
   2. The ARCNET data link / physical protocol shall not be used in new BACnet sub-networks provided as part of this project.
   3. The MS/TP data link / physical layer protocol is prohibited by the VA for use in any new BACnet network or sub-network in its healthcare or lab facilities.

B. Each controller shall have a communication port for connection to an operator interface.

C. Project drawings indicate remote buildings or sites to be connected by a nominal 56,000 baud modem over voice-grade telephone lines. In each remote location a modem and field device connection shall allow communication with each controller on the internetwork as specified in Paragraph D.

D. Internetwork operator interface and value passing shall be transparent to internetwork architecture.

1. An operator interface connected to a controller shall allow the operator to interface with each network controller as if directly connected. Controller information such as data, status, reports, system software, and custom programs shall be viewable and editable from each network controller.
2. Inputs, outputs, and control variables used to integrate control strategies across multiple controllers shall be readable by each controller on the network. Program and test all cross-controller links required to execute specified control system operation. An authorized operator shall be able to edit cross-controller links by typing a standard object address.

E. System shall be expandable to at least twice the required input and output objects with additional controllers, associated devices, and wiring. Expansion shall not require operator interface hardware additions or software revisions.

F. ECCs and Controllers with real-time clocks shall use the BACNet Time Synchronization service. The system shall automatically synchronize system clocks daily from an operator-designated device via the internetwork. The system shall automatically adjust for daylight savings and standard time as applicable.

2.4 BACNET PROTOCOL ANALYZER

A. For ease of troubleshooting and maintenance, provide a BACnet protocol analyzer. Provide its associated fittings, cables and appurtenances, for connection to the communications network. The BACnet protocol analyzer shall be able to, at a minimum: capture and store to a file all data traffic on all network levels; measure bandwidth usage; filter out (ignore) selected traffic.

2.5 NETWORK AND DEVICE NAMING CONVENTION

A. Network Numbers

1. BACnet network numbers shall be based on a "facility code, network" concept. The "facility code" is the VAMC's or VA campus' assigned numeric value assigned to a specific facility or building. The "network" typically corresponds to a "floor" or other logical configuration within the building. BACnet allows 65535 network numbers per BACnet internet work.
2. The network numbers are thus formed as follows: "Net #" = "FFFNN" where:
   a. FFF = Facility code (see below)
   b. NN = 00-99 This allows up to 100 networks per facility or building

B. Device Instances

1. BACnet allows 4194305 unique device instances per BACnet internet work. Using Agency's unique device instances are formed as follows: "Dev #" = "FFFNNDD" where:
   a. FFF and N are as above and
   b. DD = 00-99, this allows up to 100 devices per network.
2. Note Special cases, where the network architecture of limiting device numbering to DD causes excessive subnet works. The device number can be expanded to DDD and the network number N can become a single digit. In NO case shall the network number N and the device number D exceed 4 digits.
3. Facility code assignments:
4. 000-400 Building/facility number

5. Note that some facilities have a facility code with an alphabetic suffix to denote wings, related structures, etc. The suffix will be ignored. Network numbers for facility codes greater than 400 will be assigned in the range 000-399.

C. Device Names

1. Name the control devices based on facility name, location within a facility, the system or systems that the device monitors and/or controls, or the area served. The intent of the device naming is to be easily recognized. Names can be up to 254 characters in length, without embedded spaces. Provide the shortest descriptive, but unambiguous, name. For example, in building #123 prefix the number with a “B” followed by the building number, if there is only one chilled water pump "CHWP-1", a valid name would be "B123.CHWP. 1.STARTSTOP". If there are two pumps designated "CHWP-1", one in a basement mechanical room (Room 0001) and one in a penthouse mechanical room (Room PH01), the names could be "B123.R0001.CHWP.1. STARTSTOP" or "B123.RPH01.CHWP.1.STARTSTOP". In the case of unitary controllers, for example a VAV box controller, a name might be "B123.R101.VAV". These names should be used for the value of the "Object_Name" property of the BACnet Device objects of the controllers involved so that the BACnet name and the EMCS name are the same.

2.6 BACNET DEVICES

A. All BACnet Devices - controllers, gateways, routers, actuators, operator displays, and sensors shall conform to BACnet Device Profiles and shall be BACnet Testing Laboratories (BTL) -Listed as conforming to those Device Profiles. Protocol Implementation Conformance Statements (PICSs), describing the BACnet capabilities of the Devices shall be published and available for the Devices through links in the BTL website.

1. BACnet Building Controllers shall conform to the BACnet B-BC Device Profile, and shall be BTL-Listed as conforming to the B-BC Device Profile. The Device’s PICS shall be submitted.

2. BACnet Advanced Application Controllers shall conform to the BACnet B-AAC Device Profile, and shall be BTL-Listed as conforming to the B-AAC Device Profile. The Device's PICS shall be submitted.
3. BACnet Application Specific Controllers shall conform to the BACnet B-ASC Device Profile, and shall be BTL-Listed as conforming to the B-ASC Device Profile. The Device's PICS shall be submitted.
4. BACnet Smart Actuators shall conform to the BACnet B-SA Device Profile, and shall be BTL-Listed as conforming to the B-SA Device Profile. The Device's PICS shall be submitted.
5. BACnet Smart Sensors shall conform to the BACnet B-SS Device Profile, and shall be BTL-Listed as conforming to the B-SS Device Profile. The Device's PICS shall be submitted.
6. BACnet routers and gateways shall conform to the BACnet B-OTH Device Profile, and shall be BTL-Listed as conforming to the B-OTH Device Profile. The Device's PICS shall be submitted.

2.7 CONTROLLERS

A. General. Provide an adequate number of BTL listed B-BC building controllers, BTL listed B-AAC, BTL listed B-ASC, BTL listed B-SA, and BTL listed B-SS's to achieve the performance specified in the Part 1 Article on "System Performance." Each of these controllers shall meet the following requirements.
   1. Communication.
      a. Each B-BC controller shall reside on a BACnet network using the ISO 8802-3 (Ethernet) Data Link/Physical layer protocol for its communications.
      b. Each B-BC controller shall provide a service communication port using BACnet Data Link/Physical layer protocol for connection to a portable operator's terminal. If this port is not available built into the controller, contractor is to install a 4 port unmanaged switch inside the B-BC control cabinet.
   2. Keypad. A local keypad and display shall be provided for each controller. The keypad shall be provided for interrogating and editing data. Provide a system security password to prevent unauthorized use of the keypad and display.

3. Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
4. Memory. The controller shall maintain all BIOS and programming information in the event of a power loss for at least 72 hours.
5. The controller shall be able to operate at 90 percent to 110 percent of nominal voltage rating and shall perform an orderly shutdown less than 80 percent nominal voltage. Controller operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 watt at 1 meter (3 feet).
6. Transformer. Power supply for the ASC must be rated at a minimum of 125 percent of B-ASC power consumption and shall be of the fused or current limiting type.

B. Provide BTL listed B-ASC application specific controllers for each piece of equipment for which they are constructed. Application specific controllers shall communicate with other BACnet devices on the internetwork using the BACnet Read (Execute) Property service.
1. Each B-ASC shall be capable of stand-alone operation and shall continue to provide control functions without being connected to the network.
2. Each B-ASC will contain sufficient I/O capacity to control the target system.
3. Communication.
   a. Each controller shall reside on a BACnet network using the ISO 8802-3 (Ethernet) Data Link/Physical layer protocol for its communications. Each building controller also shall perform BACnet routing if connected to a network of custom application and application specific controllers.
   b. Each controller shall have a BACnet Data Link/Physical layer compatible connection for a laptop computer or a portable operator’s tool. This connection shall be extended to a space temperature sensor port where shown.

4. Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
5. Memory. The application specific controller shall use nonvolatile memory and maintain all BIOS and programming information in the event of a power loss.
6. Immunity to power and noise. Controllers shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80%. Operation shall be protected against electrical noise of 5-120 Hz and from keyed radios up to 5 watts at 1 meter (3 feet).

C. Direct Digital Controller Software
1. The software programs specified in this section shall be commercially available, concurrent, multi-tasking operating system and support the use of software application that operates under DOS, Linux, or Microsoft Windows.
2. All points shall be identified by up to 30-character point name and 16-character point descriptor. The same names shall be used at the ECC.
3. All control functions shall execute within the stand-alone control units. All new controllers installed will also include all software and/or hardware required to program, commission, or alter the sequence of operation of said controller(s). Controllers requiring software or hardware that is not commercially available will not be allowed. Installation of software and/or hardware for controller configuration will be the responsibility of the DDC contractor. COR will direct to install said hardware and/or software on either the B-AWS or portable operator terminal. The VA shall be able to customize control strategies and sequences of operations defining the appropriate control loop algorithms and choosing the optimum loop parameters without requiring the services of a DDC contractor.

4. All controllers shall be capable of being programmed to utilize stored default values for assured fail-safe operation of critical processes. Default values shall be invoked upon sensor failure or, if the primary value is normally provided by the central or another CU, or by loss of bus communication. Individual application software packages shall be structured to assume a fail-safe condition upon loss of input sensors. Loss of an input sensor shall result in output of a sensor-failed message at the ECC. Each ACU and RCU shall have capability for local readouts of all functions. The UCUs shall be read remotely.
5. All DDC control loops shall be able to utilize any of the following control modes:
   a. Two position (on-off, slow-fast) control.
   b. Proportional control.
   c. Proportional plus integral (PI) control.
   d. Proportional plus integral plus derivative (PID) control. All PID programs shall automatically invoke integral wind up prevention routines whenever the controlled unit is off, under manual control of an automation system or time-initiated program.
   e. Automatic tuning of control loops.
6. System Security: Operator access shall be secured using individual password and operator’s name. Passwords shall restrict the operator to the level of object, applications, and system functions assigned to him. A minimum of three (3)or a maximum of six (6) levels of security for operator access shall be provided.
7. Application Software: The controllers shall provide the following programs as a minimum for the purpose of optimizing energy consumption while maintaining comfortable environment for occupants. All application software shall reside and run in the system digital controllers. Editing of the application shall occur at the ECC or via a portable operator’s terminal, when it is necessary, to access directly the programmable unit.

a. Night Setback/Morning Warm up Control: The system shall provide the ability to automatically adjust set points for this mode of operation.
b. Optimum Start/Stop (OSS): Optimum start/stop program shall automatically be coordinated with event scheduling. The OSS program shall start HVAC equipment at the latest possible time that will allow the equipment to achieve the desired zone condition by the time of occupancy, and it shall also shut down HVAC equipment at the earliest possible time before the end of the occupancy period and still maintain desired comfort conditions. The OSS program shall consider both outside weather conditions and inside zone conditions. The program shall automatically assign longer lead times for weekend and holiday shutdowns. The program shall poll all zones served by the associated AHU and shall select the warmest and coolest zones. These shall be used in the start time calculation. It shall be possible to assign occupancy start times on a per air handler unit basis. The program shall meet the local code requirements for minimum outdoor air while the building is occupied. Modification of assigned occupancy start/stop times shall be possible via the ECC.
c. Event Scheduling: Provide a comprehensive menu driven program to automatically start and stop designated points or a group of points according to a stored time. This program shall provide the capability to individually command a point or group of points. When points are assigned to one common load group it shall be possible to assign variable time advances/delays between each successive start or stop within that group. Scheduling shall be calendar based and advance schedules may be defined up to one year in advance. Advance schedule shall override the day-to-day schedule. The operator shall be able to define the following information:
    1) Time, day.
    2) Commands such as on, off, auto.
    3) Time delays between successive commands.

4) Manual overriding of each schedule.

5) Allow operator intervention.

d. Alarm Reporting: The operator shall be able to determine the action to be taken in the event of an alarm. Alarms shall be routed to the ECC based on time and events. An alarm shall be able to start programs, login the event, print and display the messages. The system shall allow the operator to prioritize the alarms to minimize nuisance reporting and to speed operator's response to critical alarms. A minimum of six (6) priority levels of alarms shall be provided for each point.

e. Remote Communications: The system shall have the ability to dial out in the event of an alarm to the ECC and alpha-numeric pagers. The alarm message shall include the name of the calling location, the device that generated the alarm, and the alarm message itself. The operator shall be able to remotely access and operate the system using dial up communications. Remote access shall allow the operator to function the same as local access.

f. Maintenance Management (PM): The program shall monitor equipment status and generate maintenance messages based upon the operators defined equipment run time, starts, and/or calendar date limits. A preventative maintenance alarm shall be printed indicating maintenance requirements based on pre-defined run time. Each preventive message shall include point description, limit criteria and preventative maintenance instruction assigned to that limit. A minimum of 480-character PM shall be provided for each component of units such as air handling units.

2.8 SENSORS (AIR AND WATER)

A. Sensors' measurements shall be read back to the DDC system, and shall be visible by the ECC.

B. Temperature and Humidity Sensors shall be electronic, vibration and corrosion resistant for wall, immersion, and/or duct mounting. Provide all remote sensors as required for the systems.

1. Temperature Sensors: thermistor type for terminal units and Resistance Temperature Device (RTD) with an integral 4-20 mA or 0-10 VDC transmitter type for all other sensors.
   a. Duct sensors shall be rigid or averaging type as shown on drawings. Averaging sensor shall be a minimum of 1 linear foot of sensing element for each square foot of heating/cooling coil face area.
   b. Immersion sensors shall be provided with a separable well made of stainless steel, bronze or monel material. Pressure rating of well is to be consistent with the system pressure in which it is to be installed. Temperature well shall be filled with a thermal compound compatible with installed sensor.
   c. All space sensors shall be equipped with in-space User set-point adjustment, override switch, numerical temperature display on sensor cover, and BACnet communication port. Match room thermostats. Provide a tooled-access cover.
      1) Public space sensor: setpoint adjustment shall be only through the ECC or through the DDC system's diagnostic device/laptop. Do not provide in-space User set-point adjustment. Provide an opaque keyed-entry cover if needed to restrict in-space User set-point adjustment.
   d. Outdoor air temperature sensors shall have watertight inlet fittings and be shielded from direct sunlight.
   e. Wire: Twisted, shielded-pair cable.
   f. Output Signal: 4-20 mA or 0-10 VDC.
2. Humidity Sensors: Bulk polymer sensing element type.
   a. Duct and room sensors shall have a sensing range of 20 to 80% with accuracy of ± 2 to ± 5% RH, including hysteresis, linearity, and repeatability.
   b. Outdoor humidity sensors shall be furnished with element guard and mounting plate and have a sensing range of 0 to 100% RH.
   c. Continuous Output Signal: 4-20 mA or 0-10 VDC.

C. Static Pressure Sensors: Non-directional, temperature compensated.
   1. 4-20 mA or 0-10 VDC output signal.
   2. 0 to 5 inches wg for duct static pressure range.

3. 0 to 0.25 inch wg for Building static pressure range.

D. Flow switches:

1. Shall be either paddle or differential pressure type.
   a. Paddle-type switches (liquid service only) shall be UL Listed, SPDT snap-acting, adjustable sensitivity with NEMA 4 enclosure.
   b. Differential pressure type switches (air or water service) shall be UL listed, SPDT snap acting, NEMA 4 enclosure, with scale range and differential suitable for specified application.

E. Current Switches: Current operated switches shall be self powered, solid state with adjustable trip current as well as status, power, and relay command status LED indication. The switches shall be selected to match the current of the application and output requirements of the DDC systems.

F. Water Overflow Indicators:

1. Float Switches: Float switch manufactured to close a normally open electrical contact when water level rises at the bottom of a drain pan or sump. All parts that come in contact with water shall be plastic, brass, or stainless steel. Select switch configuration for reliable operation in the specific location it is to be used (primary drain pan, primary humidifier drain pan, secondary pan, pump sump etc.) Contact rating 4A at 24 VAC maximum and 100 mA at 5 VDC minimum. For installation the switch shall be clamped to the side of the fan or sump. Switches that required drilling through the side of the pan or sump shall be prohibited.
2. Water Sensors: 24 VAC powered solid state single pole – double throw contacts that closes upon the sensor’s detection of water at the bottom of pan, sump, floor etc. Sensor designed to be placed at the bottom of the pan, floor etc. where it will detect moisture. Sensor design shall incorporate water sensor array inside a hydrophilic pad designed to absorb and alarm with only a small amount of water. Contact rating 4A at 24 VAC maximum and 100 mA at 5 VDC minimum.

2.9 CONTROL CABLES

A. General:

1. Ground cable shields, drain conductors, and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments. Comply with Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS and Section 27 05 26, GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS.
2. Cable conductors to provide protection against induction in circuits. Crosstalk attenuation within the System shall be in excess of -80 dB throughout the frequency ranges specified.
3. Minimize the radiation of RF noise generated by the System equipment so as not to interfere with any audio, video, data, computer main distribution frame (MDF), telephone customer service unit (CSU), and electronic private branch exchange (EPBX) equipment the System may service.
4. The as-installed drawings shall identify each cable as labeled, used cable, and bad cable pairs.
5. Label system’s cables on each end. Test and certify cables in writing to the VA before conducting proof-of-performance testing. Minimum cable test requirements are for impedance compliance, inductance, capacitance, signal level compliance, opens, shorts, cross talk, noise, and distortion, and split pairs on all cables in the frequency ranges used. Make available all cable installation and test records at demonstration to the VA. All changes (used pair, failed pair, etc.) shall be posted in these records as the change occurs.
6. Power wiring shall not be run in conduit with communications trunk wiring or signal or control wiring operating at 100 volts or less.

B. Analogue control cabling shall be not less than No. 18 AWG solid or stranded, with thermoplastic insulated conductors as specified in Section 26 05 21.

C. Copper digital communication cable between the ECC and the B-BC and B-AAC controllers shall be 100BASE-TX Ethernet, Category 5e or 6, not less than minimum 24 American Wire Gauge (AWG) solid, Shielded Twisted Pair (STP) or Unshielded Twisted Pair (UTP), with thermoplastic insulated conductors, enclosed in a thermoplastic outer jacket, as specified in Section 27 15 13, COMMUNICATIONS COPPER HORIZONTAL CABLING.
   1. Other types of media commonly used within IEEE Std 802.3 LANs (e.g., 10Base-T and 10Base-2) shall be used only in cases to interconnect with existing media.

D. All MS/TP communications cables for devices utilizing the EIA-485 standard must be listed for use on EIA-485 networks by the manufacturer of the cable. This requirement overrides any cable recommendation by the controller manufacturer. The use of EIA-485 communication cables shall not affect the warranty from the installing DDC contractor. Cables shall have the following characteristic:
   1. Nominal Impedance: 100-130 Ohms
   2. Twisted/shielded construction of 1, 1.5, or 2 pairs depending on controller requirements.
   3. Be plenum rated when required
   4. Cables designated for use by the cable manufacturer for use in PA or Speaker systems shall not be allowed, regardless of recommendations by the controller manufacturer.

E. Optical digital communication fiber, if used, shall be Multimode or Single mode fiber, 62.5/125 micron for multimode or 10/125 micron for single mode micron with SC or ST connectors as specified in TIA-568-C.1. Terminations, patch panels, and other hardware shall be compatible with the specified fiber and shall be as specified in Section 27 13 23, COMMUNICATIONS OPTICAL FIBER BACKBONE CABLING. Fiber-optic cable shall be suitable for use with the 100Base-FX or the 100Base-SX standard (as applicable) as defined in IEEE Std 802.3.

2.10 THERMOSTATS AND HUMIDISTATS

A. Room thermostats controlling unitary standalone heating and cooling devices not connected to the DDC system shall have three modes of operation (heating - null or dead band - cooling). Thermostats for patient bedrooms shall have capability of being adjusted to eliminate null or dead band. Wall mounted thermostats shall have polished or brushed aluminum finish, setpoint range and temperature display and external adjustment:

1. Electronic Thermostats: Solid-state, microprocessor based, BACnet enabled, programmable to daily, weekend, and holiday schedules.
   a. Public Space Thermostat: Public space thermostat shall have a thermistor sensor and shall not have a visible means of set point adjustment. Adjustment shall be via the digital controller to which it is connected.
   b. Battery replacement without program loss.

2.11 FINAL CONTROL ELEMENTS AND OPERATORS

A. Fail Safe Operation: Control valves and dampers shall provide "fail safe" operation in either the normally open or normally closed position as required for freeze, moisture, and smoke or fire protection.

B. Spring Ranges: Range as required for system sequencing and to provide tight shut-off.

C. Power Operated Control Dampers (other than VAV Boxes): Factory fabricated, balanced type dampers. All modulating dampers shall be opposed blade type and gasketed. Blades for two-position, duct-mounted dampers shall be parallel, airfoil (streamlined) type for minimum noise generation and pressure drop.

1. Leakage: Except as specified in subparagraph 2 below, maximum leakage in closed position shall not exceed 7 L/S (15 CFMs) differential pressure for outside air and exhaust dampers and 200 L/S/ square meter (40 CFM/sq. ft.) at 50 mm (2 inches) differential pressure for other dampers.
2. Frame shall be galvanized steel channel with seals as required to meet leakage criteria.

3. Blades shall be galvanized steel or aluminum, 200 mm (8 inch) maximum width, with edges sealed as required.
4. Bearing shall be nylon, bronze sleeve or ball type.
5. Hardware shall be zinc-plated steel. Connected rods and linkage shall be non-slip. Working parts of joints shall be brass, bronze, nylon or stainless steel.
6. Maximum air velocity and pressure drop through free area the dampers:
   a. Smoke damper in air handling unit: 305 meter per minute (1000 fpm).
   b. Duct mounted damper: 600 meter per minute (2000 fpm).
   c. Maximum static pressure loss: 50 Pascal (0.20 inches water gage).

D. Smoke Dampers and Combination Fire/Smoke Dampers: Dampers and operators are specified in Section 23 31 00, HVAC DUCTS AND CASINGS. Control of these dampers is specified under this Section.

E. Control Valves:
1. Valves shall be rated for a minimum of 150 percent of system operating pressure at the valve location but not less than 900 kPa (125 psig).
2. Valves 50 mm (2 inches) and smaller shall be bronze body with threaded or flare connections.
3. Valves 60 mm (2 1/2 inches) and greater shall be bronze or iron body with flanged connections.
4. Brass or bronze seats except for valves controlling media greater than 100 degrees C (210 degrees F), which shall have stainless steel seats.
5. Flow characteristics:
   a. Three way modulating valves shall be globe pattern. Position versus flow relation shall be linear relation for steam or equal percentage for water flow control.
   b. Two-way modulating valves shall be globe pattern. Position versus flow relation shall be linear for steam and equal percentage for water flow control.

c. Two-way 2-position valves shall be ball, gate or butterfly type.

6. Maximum pressure drop:
   a. Two position steam control: 20 percent of inlet gauge pressure.
   b. Modulating Steam Control: 80 percent of inlet gauge pressure (acoustic velocity limitation).
   c. Modulating water flow control, greater of 3 meters (10 feet) of water or the pressure drop through the apparatus.
7. Two position water valves shall be line size.

F. Damper and Valve Operators and Relays:
1. Electric operator shall provide full modulating control of dampers and valves. For dampers a linkage and pushrod shall be furnished for mounting the actuator on the damper frame internally in the duct, externally in the duct, externally on the duct wall, or shall be furnished with a direct-coupled design. Metal parts shall be aluminum, mill finish galvanized steel, or zinc plated steel or stainless steel. Provide actuator heads which allow for electrical conduit attachment. The motor(s) shall have sufficient closure torque to allow for complete closure of valve or damper under pressure. Provide multiple motors as required to achieve sufficient close-off torque.
   a. Minimum valve close-off pressure shall be equal to the system pump’s dead-head pressure, minimum 50 psig for valves smaller than 4 inches.
2. Electronic damper operators: Metal parts shall be aluminum, mill finish galvanized steel, or zinc plated steel or stainless steel. Provide actuator heads which allow for electrical conduit attachment. The motors shall have sufficient closure torque to allow for complete closure of valve or damper under pressure. Provide multiple motors as required to achieve sufficient close-off torque.
3. See drawings for required control operation.

2.12 SAFETY

A. Provide hard-wired interlocked connections for such all safety devices, such as freeze stats, smoke detectors, smoke dampers, and refrigerant leak detection devices. All safety devices shall be provided with additional dry contacts and shall be connected to the DDC system for monitoring and sequencing.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General:

1. Examine project plans for control devices and equipment locations; and report any discrepancies, conflicts, or omissions to COR for resolution before proceeding for installation.
2. Install equipment, piping, wiring/conduit parallel to or at right angles to building lines.
3. Install all equipment and piping in readily accessible locations. Do not run tubing and conduit concealed under insulation or inside ducts.
4. Mount control devices, tubing and conduit located on ducts and apparatus with external insulation on standoff support to avoid interference with insulation.
5. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.
6. Run tubing and wire connecting devices on or in control cabinets parallel with the sides of the cabinet neatly racked to permit tracing.
7. Install equipment level and plumb.

B. Electrical Wiring Installation:

1. All wiring and cabling shall be installed in conduits. Install conduits and wiring in accordance with Specification Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS. Conduits carrying control wiring and cabling shall be dedicated to the control wiring and cabling: these conduits shall not carry power wiring. Provide plastic end sleeves at all conduit terminations to protect wiring from burrs.

a. Minimum conduit size shall be 3/4 inch.

2. Install analog signal and communication cables in conduit and in accordance with Specification Division 27 - COMMUNICATIONS. Install digital communication cables in conduit and in accordance with Specification Section 27 10 00, STRUCTURED CABLING and Section 27 15 13, COPPER HORIZONTAL CABLING.
3. Install conduit and wiring between operator workstation(s), digital controllers, electrical panels, indicating devices, instrumentation, miscellaneous alarm points, thermostats, and relays as shown on the drawings or as required under this section.
4. Install all electrical work required for a fully functional system and not shown on electrical plans or required by electrical specifications. Where low voltage (less than 50 volt) power is required, provide suitable Class B transformers.
5. Install all system components in accordance with local Building Code and National Electric Code.
   a. Splices: Splices in shielded and coaxial cables shall consist of terminations and the use of shielded cable couplers. Terminations shall be in accessible locations. Cables shall be harnessed with cable ties.
   b. Equipment: Fit all equipment contained in cabinets or panels with service loops, each loop being at least 300 mm (12 inches) long. Equipment for fiber optics system shall be rack mounted, as applicable, in ventilated, self-supporting, code gauge steel enclosure. Cables shall be supported for minimum sag.
   c. Cable Runs: Keep cable runs as short as possible. Allow extra length for connecting to the terminal board. Do not bend flexible coaxial cables in a radius less than ten times the cable outside diameter.
   d. Use vinyl tape, sleeves, or grommets to protect cables from vibration at points where they pass around sharp corners, through walls, panel cabinets, etc.
6. Conceal cables, except in mechanical rooms and areas where other conduits and piping are exposed.

7. Permanently label or code each point of all field terminal strips to show the instrument or item served. Color-coded cable with cable diagrams may be used to accomplish cable identification.
8. Grounding: ground electrical systems per manufacturer's written requirements for proper and safe operation.

C. Install Sensors and Controls:

1. Temperature Sensors:
   a. Install all sensors and instrumentation according to manufacturer's written instructions. Temperature sensor locations shall be readily accessible, permitting quick replacement and servicing of them without special skills and tools.
   b. Calibrate sensors to accuracy specified, if not factory calibrated.
   c. Use of sensors shall be limited to its duty, e.g., duct sensor shall not be used in lieu of room sensor.
   d. Install room sensors permanently supported on wall frame. They shall be mounted at 1.5 meter (5.0 feet) above the finished floor unless otherwise noted on the plans or drawings.
   e. Mount sensors rigidly and adequately for the environment within which the sensor operates. Separate extended-bulb sensors form contact with metal casings and coils using insulated standoffs.
   f. Sensors used in mixing plenum, and hot and cold decks shall be of the averaging of type. Averaging sensors shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip.
   g. All pipe mounted temperature sensors shall be installed in wells.
   h. All wires attached to sensors shall be air sealed in their conduits or in the wall to stop air transmitted from other areas affecting sensor reading.

i. Permanently mark terminal blocks for identification. Protect all circuits to avoid interruption of service due to short-circuiting or other conditions. Line-protect all wiring that comes from external sources to the site from lightning and static electricity.

2. Pressure Sensors:
   a. Install duct static pressure sensor tips facing directly downstream of airflow.
   b. Install high-pressure side of the differential switch between the pump discharge and the check valve.
   c. Install snubbers and isolation valves on steam pressure sensing devices.
3. Actuators:
   a. Mount and link damper and valve actuators according to manufacturer’s written instructions.
   b. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed position.
   c. Check operation of valve/actuator combination to confirm that actuator modulates valve smoothly in both open and closed position.
4. Flow Switches:
   a. Install flow switches according to manufacturer’s written instructions.
   b. Mount flow switches a minimum of 5 pipe diameters upstream and 5 pipe diameters downstream or 600 mm (2 feet) whichever is greater, from fittings and other obstructions.
   c. Assure correct flow direction and alignment.
   d. Mount in horizontal piping-flow switch on top of the pipe.

D. Installation of network:
1. Ethernet:
   a. The network shall employ Ethernet LAN architecture, as defined by IEEE 802.3. The Network Interface shall be fully Internet Protocol (IP) compliant allowing connection to currently installed IEEE 802.3, Compliant Ethernet Networks.

b. The network shall directly support connectivity to a variety of cabling types. As a minimum provide the following connectivity: 100 Base TX (Category 5e cabling) for the communications between the ECC and the B-BC and the B-AAC controllers.

2. Third party interfaces: Contractor shall integrate real-time data from building systems by other trades and databases originating from other manufacturers as specified and required to make the system work as one system.

E. Installation of digital controllers and programming:

1. Provide a separate digital control panel for each major piece of equipment, such as air handling units, etc. Points used for control loop reset such as outdoor air, outdoor humidity, or space temperature could be located on any of the remote control units.
2. Provide sufficient internal memory for the specified control sequences and trend logging. There shall be a minimum of 25 percent of available memory free for future use.
3. System point names shall be human-readable, permitting easy operator interface without the use of a written point index.
4. Provide software programming for the applications intended for the systems specified, and adhere to the strategy algorithms provided.
5. Provide graphics for each piece of equipment and floor plan in the building. This includes each air handling unit, fan, terminal unit, and CRAC system, etc. These graphics shall show all points dynamically as specified in the point list.

3.2 SYSTEM VALIDATION AND DEMONSTRATION

A. As part of final system acceptance, a system demonstration is required (see below). Prior to start of this demonstration, the contractor is to perform a complete validation of all aspects of the controls and instrumentation system. When formal commissioning is included in the project the system validation/test shall be part of the commissioning and shall be witnessed by the CxA.

B. Validation

1. Prepare and submit for approval a validation test plan including test procedures for the performance verification tests. Test Plan shall be submitted for review with the control system submittal as indicated in paragraph 1.7 Submittals. Test Plan address all specified functions of the ECC and all specified sequences of operation. Explain in detail actions and expected results used to demonstrate compliance with the requirements of this specification. Explain the method for simulating the necessary conditions of operation used to demonstrate performance of the system. Test plan shall include a test check list to be used by the Installer's agent to check and initial that each test has been successfully completed. Deliver test plan documentation for the performance verification tests to the owner's representative 30 days prior to start of performance verification tests. Provide draft copy of operation and maintenance manual with performance verification test.
2. After approval of the validation test plan, installer shall carry out all tests and procedures therein. Installer shall completely check out, calibrate, and test all connected hardware and software to ensure that system performs in accordance with approved specifications and sequences of operation submitted. Installer shall complete and submit Test Check List.

C. Demonstration

1. System operation and calibration to be demonstrated by the installer in the presence of the A/E, CxA, or COR on random samples of equipment as dictated by the COR. Should random sampling indicate improper work, the owner reserves the right to subsequently witness complete calibration of the system at no addition cost to the VA.
2. Make accessible, personnel to provide necessary adjustments and corrections to systems as directed by balancing agency.
3. The following witnessed demonstrations of field control equipment shall be included:

a. Observe HVAC systems in shut down condition. Check dampers and valves for normal position.
b. Test application software for its ability to communicate with digital controllers, operator workstation, and uploading and downloading of control programs.
c. Demonstrate the software ability to edit the control program off-line.
d. Demonstrate reporting of alarm conditions for each alarm and ensure that these alarms are received at the assigned location, including operator workstations.
e. Demonstrate ability of software program to function for the intended applications-trend reports, change in status etc.
f. Demonstrate via graphed trends to show the sequence of operation is executed in correct manner, and that the HVAC systems operate properly through the complete sequence of operation, e.g., seasonal change, occupied/unoccupied mode, and warm-up condition.
g. Demonstrate hardware interlocks and safeties functions, and that the control systems perform the correct sequence of operation after power loss and resumption of power loss.
h. Prepare and deliver to the VA graphed trends of all control loops to demonstrate that each control loop is stable and the set points are maintained.
i. Demonstrate that each control loop responds to set point adjustment and stabilizes within 5 minutes. Control loop trend data shall be instantaneous and the time between data points shall not be greater than 1 minute.

4. Witnessed demonstration of ECC functions shall consist of:
   a. Running each specified report.
   b. Display and demonstrate each data entry to show site specific customizing capability. Demonstrate parameter changes.
   c. Step through penetration tree, display all graphics, demonstrate dynamic update, and direct access to graphics.
   d. Execute digital and analog commands in graphic mode.

e. Demonstrate DDC loop precision and stability via trend logs of inputs and outputs (6 loops minimum).
f. Demonstrate Energy Management System (EMS) performance via trend logs and command trace.
g. Demonstrate scan, update, and alarm responsiveness.
h. Demonstrate spreadsheet/curve plot software, and its integration with database.
i. Demonstrate on-line user guide, and help function and mail facility.
j. Demonstrate digital system configuration graphics with interactive upline and downline load, and demonstrate specified diagnostics.
k. Demonstrate multitasking by showing dynamic curve plot, and graphic construction operating simultaneously via split screen.
l. Demonstrate class programming with point options of beep duration, beep rate, alarm archiving, and color banding.

3.3 STARTUP AND TESTING

A. Perform tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.
B. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.
C. The CxA will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the COR and CxA. Provide a minimum notice of 10 working days prior to startup and testing.

3.4 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

3.5 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer’s technical representative for 8 hours to instruct each VA Personnel responsible in operation and maintenance of the system.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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SECTION 23 09 27
DATA CENTER COOLING OPTIMIZATION SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. The Contractor shall provide a data center cooling optimization system as indicated on the project documents, points list(s), interoperability table(s), drawings, and as described in these specifications. Provide a complete and working system to monitor CRAC unit operation and data center environmental conditions and to automatically manage CRAC system operations to maintain optimum environmental conditions and maximize energy efficiency. Include all engineering, programming, configuration/setup hardware and software, controls and installation materials, installation labor, commissioning and start-up, training, final project documentation and warranty.

B. The DCCO system herein specified shall be fully functional and will ultimately operate as a complete, unified tool for the owner. Deployment shall include all software installation, hardware installation, calibration, and testing necessary to furnish a fully operational dynamic cooling optimization system.

1.2 RELATED WORK

A. Related specifications include but are not limited to those shown below. Coordinate all work with the applicable specification for that work.

B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

D. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

E. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

F. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

G. Section 23 81 23, COMPUTER ROOM AIR-CONDITIONERS.

H. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

I. Section 26 05 19, L0W-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW).

J. Section 26 05 26, CROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

K. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS.

L. Section 26 27 26, WIRING DEVICES.
M. Section 27 05 11, REQUIREMENTS FOR COMMUNICATIONS INSTALLATIONS.
N. Section 27 05 26, GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS.
O. Section 27 05 33, CONDUITS AND BACKBOXES FOR COMMUNICATIONS SYSTEMS.
P. Section 27 05 36, CABLE TRAYS FOR COMMUNICATIONS SYSTEMS.
Q. Section 27 10 00, STRUCTURED CABLING.
R. Section 27 11 00, COMMUNICATIONS EQUIPMENT ROOM FITTINGS.
S. Section 27 11 16, COMMUNICATIONS CABINETS, RACKS, FRAMES, AND ENCLOSURES.
T. Section 27 13 13, COMMUNICATIONS COPPER BACKBONE CABLING.
U. Section 27 13 13.13, COMMUNICATIONS COPPER CABLE SPLICING AND TERMINATIONS.
V. Section 27 15 13, COMMUNICATIONS COPPER HORIZONTAL CABLING.
W. Section 27 16 19, COMMUNICATIONS PATCH CORDS, STATION CORDS, AND CROSS CONNECT WIRE.
X. Section 28 31 00, FIRE DETECTION AND ALARM.

1.3 ABBREVIATIONS/ACRONYMS

A. A complete listing of common acronyms and abbreviations are included in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
B. DCCO: data center cooling optimization

1.4 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Where conflicts occur these specifications and the VA standard will govern.
B. IEEE Standards Association
    1. 802.15.4-2024 Standard for Low-Rate Wireless Networks
    2. 802.15.4e-2012 Standard for Local and metropolitan area networks--Part 15.4: Low-Rate Wireless Personal Area Networks (LR-WPANs) Amendment 1: MAC sublayer

1.5 QUALITY ASSURANCE

A. Refer to article, QUALITY ASSURANCE in specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

B. System manufacturer shall have a minimum of 5 years experience producing similar systems, and shall have installed a minimum of 10 similar systems.
C. Vendor qualifications: Vendor shall be a firm engaged in the sale and deployment of the required type of DCCO system, whose products have been successfully used in the field for a minimum of one year.
D. Contractor qualifications: Any third-party contractors shall be vetted by the vendor. Contractor shall be an individual or firm with suitable experience working on data center infrastructure projects similar in type and scope to this project.
E. The vendor shall continually monitor the field installation for code compliance and quality of workmanship.

1.6 SUBMITTALS

A. Submittals, including general content requirements, format, media, & number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES and Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
B. Manufacturer’s Literature and Data
    1. DCCO system requirements
    2. Planning Guides
    3. Hardware Installation Guides
    4. Wiring diagrams
    5. Hardware data sheets
    6. Informative documents
    7. Kick-off meeting presentation
    8. RACI matrix
    9. MOP template
    10. Floorplans with proposed sensor locations
    11. User access configuration information
    12. Settings spreadsheets
    13. Project schedule
    14. IP address request form
C. Shop Drawings
D. Calculations
E. Manufacturer Qualifications

F. Installer Qualifications

G. Operation & Maintenance Information

1. Submit in accordance with Article, INSTRUCTIONS, in Specification Section 01 00 00, GENERAL REQUIREMENTS.
2. Include the following documentation:
   a. General description and specifications for all components, including logging on/off, alarm handling, producing trend reports, overriding computer control, and changing set points and other variables.
   b. Detailed illustrations of all the control systems specified for ease of maintenance and repair/replacement procedures, and complete calibration procedures.
   c. One copy of the final version of all software provided including operating systems, programming language, operator workstation software, and graphics software.
   d. Complete troubleshooting procedures and guidelines for all systems.
   e. Complete operating instructions for all systems.
   f. Recommended preventive maintenance procedures for all system components including a schedule of tasks for inspection, cleaning and calibration. Provide a list of recommended spare parts needed to minimize downtime.
   g. Training Manuals: Submit the course outline and training material to the Owner for approval three (3) weeks prior to the training to VA facility personnel. These persons will be responsible for maintaining and the operation of the control systems, including programming. The Owner reserves the right to modify any or all of the course outline and training material.
   h. Licenses, guaranty, and other pertaining documents for all equipment and systems.

H. Warranty Certifications

I. Test Results

J. Certifications

K. Manufacturer Startup Reports

L. Licenses: Provide licenses for all software residing on and used by the DCCO system and transfer these licenses to the Owner prior to completion.
M. Software Tools: Provide copy of all required software tools, access codes, graphics libraries, and hardware, etc., required to work on DCCO system software, to the VA at project closeout.
N. As-Built Documentation
    1. Comply with requirements in Paragraph “AS-BUILT DOCUMENTATION” of Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
O. Commissioning System Readiness Checklists
P. Training Plans
Q. Training Instructor Qualifications

1.7 DELIVERY, STORAGE, & HANDLING

A. Comply with requirements in paragraph DELIVERY, STORAGE AND HANDLING of Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
B. Accept products on site in factory packaging.
C. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

PART 2 - PRODUCTS

2.1 SYSTEM OVERVIEW

A. The DCCO system shall be a software appliance with associated optional hardware devices.
B. The DCCO system shall provide continuous monitoring of data center rack temperatures, cooling unit supply and return air temperatures, and cooling unit power usage.
C. The DCCO system shall provide autonomous control of facility cooling units.
D. The DCCO control software shall allocate cooling to maintain rack inlet air temperatures near or below user-specified upper limit targets.
E. Depending on site-specific deployment needs, the DCCO system shall be available in a software-only implementation that does not require DCCO system hardware components.

F. The DCCO system shall support implementation in a variety of facility configurations, including:
   1. Data centers with raised or slab floors
   2. Data centers with chilled water, DX, or economizer cooling infrastructure
   3. Data centers with cooling units featuring variable fan (VFD or EC fan) and/or start/stop operation.

G. Installation of the DCCO system shall not be disruptive to data center functioning, or require suspension of data center operation.

2.2 SYSTEM SOFTWARE SUMMARY

A. The DCCO control software shall be a dedicated, stand-alone appliance that receives telemetry from environmental and electrical sensors, stores and analyzes that data, and transmits control commands to cooling units as needed.

B. The DCCO software appliance shall be able to be hosted on a physical server or a VMware virtual machine.

C. The DCCO software shall automatically and dynamically adjust white space facility cooling to match IT load in real-time.

D. The DCCO software shall control cooling based on the configured rack sensor high set point upper temperature limits for the inlet air temperature of IT equipment.

E. The DCCO software shall adapt to variations in facility layout or IT load and automatically re-optimize cooling after changes occur.

F. The DCCO software shall employ machine learning to correlate sensor data with implemented cooling control decisions in order to learn from its own actions.

G. The DCCO software shall create and maintain an up-to-date empirical model of the thermal influence of each cooling unit on sensor temperatures across the data center floor, and use this model to predict the results of its cooling control decisions before implementing them.

H. The DCCO software shall provide a graphical user interface (GUI) for operators.

2.3 DCCO SYSTEM HARDWARE SUMMARY

A. A typical implementation of the DCCO system shall include some or all of the following hardware components, to be provided by vendor:

B. Server – a standard 1U rack server configured by vendor shall host the system control software and associated database.

C. Wireless sensor modules – sensors which measure the air inlet temperature via dual-thermistor wire assembly at IT racks across the data center floor, and transmit that data to the system server.

D. Wireless control modules – devices which are capable of cooling unit monitoring and actuation, including implementing control commands from the DCCO software.

E. Wireless network managers – devices which establish and maintain the wireless mesh network used by the control software to communicate with control modules, and by sensors and control modules to relay data back to the control software.

2.4 SYSTEM DESCRIPTION

A. System Architecture & Interfaces

1. The DCCO system shall manage data and devices through a system of site points and device points. Site points shall be configurable, and include sensor points, control points, and calculated data points.
2. The DCCO system architecture shall allow scalability of system site points and hardware devices to accommodate different size data centers with variable capacities.
3. The DCCO system shall be able to support standard interfaces to provide connectivity to facility network infrastructure, cooling infrastructure, Building Management Systems (BMS), IT devices, and other hardware.

B. Communication Protocols

1. The DCCO system shall be able to communicate through the following protocols:
2. TCP/IP – standard protocol governing connection of computer devices to the Internet
3. BACnet/IP – a communication protocol commonly used by BMS and automation systems

4. Modbus TCP – a communication protocol used to control electronic devices
5. SNMP – a communication protocol used for gathering information about managed devices

C. DCCO System Capabilities
1. The DCCO System shall have the following capabilities:
2. The DCCO system shall individually monitor and control the environment in thermally isolated areas, rooms, or floors.
3. The DCCO system shall have a client-server architecture consisting of a real-time server and remote client which can be accessed via web browser.
4. The DCCO system shall provide users with the ability to bypass and/or override software control to turn cooling units on and off, and set their fan speed (where supported).
5. The DCCO system shall feature a Public API which can be accessed by users in order to retrieve data from, or deliver commands to, the DCCO control software.
6. The DCCO system shall allow for monitor and control of up to 6,500 site points.
7. The DCCO system shall monitor rack server air inlet temperatures at two measurement points (top and bottom) of every third active IT rack in the facility.
8. Rack temperature sensor data shall be saved locally and used by the DCCO software to understand facility cooling needs, and to guide cooling allocation.
9. The DCCO system shall control facility cooling units, turning them on and off and (where supported) adjusting their fan speed as needed. Control over cooling units shall be established using one of three methods:
   a. Wireless control module, provided and installed by the vendor
   b. Direct digital control via facility LAN or WAN via Modbus TCP or BACnet/IP
   c. Digital control via integration with facility BMS via Modbus TCP or BACnet/IP

10. The DCCO system shall monitor cooling units under its control via installed sensors. Each cooling unit’s return air temperature (RAT), discharge air temperature (DAT), and instantaneous power consumption shall be routinely transmitted to the control software.
11. The DCCO system shall support SNMPv2c polling and be capable of sending SNMPv3 Trap messages to a configured receiver.

D. DCCO System Hardware
   1. Server
      a. For physical implementations, the DCCO software appliance shall be available hosted on a 1U rack-mountable server. The server shall feature dual hot-swappable drives, dual power connections, and dual Ethernet ports.
   2. Networking
      a. The DDCO system shall be connected via wired connections, and may include use of facility DDC and LAN systems as well as wired connections used soley for the DCCO system.
      b. Wiring products and installation shall comply with Division 27 requirements.
   3. Sensors
      a. The DCCO system shall include sensors capable of measuring environmental data and transmitting that data to the server via the wired network connections.
      b. All sensors shall be addressable on the DCCO network.
      c. Sensors on a single rack/cabinet may be daisy chained.
      d. Temperature Sensors
         1) Sensor measures rack inlet or outlet air temperature via two thermistors connected to the sensor module by a wire assembly.
      e. Humidity Sensors
         1) Sensor measures relative humidity via an internal hygrometer and temperature sensor.
      f. Temperature/Humidity Sensors

1) Sensor measures rack inlet or outlet air temperature via two thermistors connected to the sensor module by a wire assembly.
2) Sensor measures relative humidity via an internal hygrometer and temperature sensor.

4. Control Modules
   a. Control modules shall connect to the server via the wired network connections. Control modules shall implement real-time control instructions from the DCCO software, turning their cooling unit on or off, and controlling its fan speed (where supported). Control modules shall collect sensor readings measuring the cooling unit’s return air temperature, discharge air temperature, and power usage, and transmit this data to the DCCO server.
      1) Sensor readings from CRAC unit onboard controls and sensors may be utilized via the facility DDC system integration in lieu of providing separate sensors, where the required data is available via the facility DDC system.
5. Rack Control Module
   a. Smart rack controller with 2 x C14 power inputs, 8 x RJ-45 sensor port, 1 x RJ-45 RS-485 port, 2 x USB-A port, 1 x USB-B port, 2 x RJ-45 (10/100/1000 Mbps) Ethernet port, 1 x RJ-45 feature port, with built in 2 x RJ-45 port to connect remote hubs, multi-color LCD display.
6. Approved Products
   a. DCCO system hardware devices purchased from vendor shall be manufactured by or for vendor to vendor’s specifications. For servers, network managers, and control modules, equivalent products by other manufacturers are not acceptable. The DCCO system shall support the use of third-party wireless rack temperature sensors so long as the devices meet the specified technical requirements of the DCCO system.
   b. DCCO system shall be as manufactured by Vigilent.

1) Private-labeled versions of Vigilent DCCO system, including Cooling Optimize by Schneider Electric, shall be acceptable.

E. DCCO System Software

1. General

a. The DCCO software shall be installed on a physical or VMware server running a Linux operating system that can be accessed remotely via client by qualified personnel.

b. The DCCO software shall be able to integrate with third-party solutions through APIs.

c. The DCCO software shall have a database back-up tool.

d. The DCCO software shall have the capability to export selected historical data in CSV format.

e. The DCCO software shall have the capability to import certain configuration settings in CSV format.

f. The DCCO software shall provide users with the ability to import floorplan images into the system software.

g. The DCCO software shall provide users with the ability to search data and assets via the user interface.

h. The DCCO software shall provide users with the ability generate downloadable reports in PDF file format.

2. Thermal Influence Model

a. The DCCO software shall use machine learning to create and maintain an up-to-date empirical computer model of the thermal influence of every cooling unit over every rack sensor on the data center floor.

1) The DCCO software shall create this computer model by observing the impact that making changes to cooling within a thermally isolated area (i.e., turning cooing units on/off and adjusting their fan speeds) has on rack temperatures.

2) The DCCO software control algorithm shall use this influence model to predict the result of its control actions before issuing control commands to increase or decrease cooling.

3) The DCCO software GUI shall provide an interactive visual representation of the current thermal influence model for each room in the data center under DCCO system control.

3. User Accounts & Roles
   a. The DCCO system administrator shall be able to control which tasks users, or groups of users, are able to execute via the GUI.
   b. The DCCO system shall support multiple users, each with unique log-in credentials.
   c. The DCCO system shall have multiple user roles which can be assigned to users; different roles shall have different permissions with associated capabilities.
   d. The DCCO system shall enable administrators to create new, custom roles with configured permissions.
   e. An administrator shall have full read/write access to all DCCO system functionality.
   f. The DCCO system shall allow the system administrator to create user accounts ranging from administrator access to view-only access.
   g. View-only access users shall not be able to change the DCCO system configuration.
4. Historical Data and Archiving
   a. Sensor data shall be stored locally on the DCCO server as follows:
      1) One-minute intervals shall be stored for 18 months.
         (a) Fifteen-minute and hourly intervals shall be stored for five years.
         (b) Daily, weekly, monthly, and annual intervals shall be stored forever.
   b. Parameters of data retention shall be configurable.
   c. Saved data shall be available to users via the GUI, where it can be trended in time-series format.
   d. Saved data shall be available for users to download in the form of a back-up file exported from the GUI according to user-configured parameters.

5. Graphical User Interface
   a. The DCCO system shall have a browser-based GUI that includes:
      1) Dashboard Tab
         (a) This tab features multiple dynamically updated widgets allowing for at-a-glance system review.
      2) Rack Sensor Tab
         (a) This tab features current rack sensor temperatures and configurable rack sensor set points.
      3) Cooling Unit Tab
         (a) This tab features cooling unit RAT, DAT, and power usage sensor data and cooling unit override controls.
      4) Facility Maps Tab
         (a) This tab features facility floorplans overlaid with real-time thermographic, thermal influence, and system asset information.
      5) Trends Tab
         (a) This tab features ability to trend all saved system data points in time-series format.
      6) Live Tab
         (a) This tab features the latest sensor data associated with selected hardware devices.
      7) Reports Tab
         (a) This tab features custom reports which can be run by the user and downloaded in PDF format.
      8) Notifications Tab
         (a) This tab features active system alarms and searchable event log.
6. Graphical User Interface Capabilities
   a. Users shall have the ability to perform the following tasks via the GUI:
      1) Trend Historical Data
         (a) Users shall be able to trend the following data points in time-series format:
         (b) Inlet air temperatures at the top and bottom of each rack

(c) Cooling unit RAT and DAT
(d) Cooling unit instantaneous power consumption
(e) Cooling unit on/off state
(f) Fan speed of a cooling unit with a VFD or EC fan, displayed as a percentage of the maximum possible speed.
(g) Cooling rate – the thermal power (energy per unit time) an AHU removes from the room.
(h) Cooling unit output, as a percentage of maximum possible output.
(i) Estimated COP – A real-time estimate of a cooling unit’s efficiency.
(j) Estimated mechanical functioning state of the cooling unit.
(k) Computed point indicating the disparity between the observed state of the unit and its commanded state.
(l) Humidity – The percent relative humidity measured at this location.
(m) Pressure – The air pressure measured at this location.
(n) The amount of cooling being delivered by the DCCO system over time, as a percentage of total cooling capability.
(o) The amount of cooling air pressure being requested as a percentage of how much is being delivered.
(p) Computed coefficient of performance for all cooling units in the selected room.
(q) The calculated accuracy of the thermal influence model over time.
(r) The mismatch between what the DCCO control software wants in the way of cooling and what it can get, based on various hardware factors. The metric is the number of cooling units it can turn on or off.
(s) The sum of the computed cooling rate for all cooling units in the currently selected room.

(t) The total amount of energy being used by all of the AHUs in the currently selected room.

2) Identify hot and cold spots on the data center floor

3) Identify unreachable DCCO system hardware devices

4) View color-coded floorplan visualizations:

(a) visual representation of current temperatures in the white space.

(b) visual representation of the cooling and heating influence of each cooling unit

(c) visual representation of all deployed DCCO system hardware devices

5) Run Reports

(a) The DCCO system shall provide users with the ability to run customizable, downloadable reports regarding system performance and cooling infrastructure including:

(b) Energy usage report – allows the user to compare total facility cooling power usage during two specified time frames.

(c) Rack temperature compliance report – allows the user to compare rack temperatures to configured thresholds during a specified time frame.

(d) Cooling capacity report – allows the user to view cooling usage at site, room, and cooling unit level during a specified time frame.

(e) Cooling unit performance report – allows the user view cooling unit efficiency, fan speed, and run hours during a specified time frame.

7. Managing System Assets

a. The DCCO system shall allow users to add or remove wireless network managers and sensor modules to/from the system, and to configure them as needed for operation or storage.

1) The DCCO system shall provide the capability to add custom names to hardware devices.

8. Alarms and Notifications

a. The DCCO system shall allow the operator to define custom values for certain alarm thresholds.
b. The DCCO software shall provide users with the ability to suppress or unsuppress currently asserted alarms.
c. The DCCO software shall keep a record of all alarm triggering events with detailed event information.
d. Capability to see all currently asserted alarms in the system in a single view.
e. Alarm details shall include a time-of-day stamp and be color-coded based on severity.
f. Ability to view assets and their associated alarms in a hierarchical manner.

F. SNMP Features
1. Provide the following optional SNMP features as part of the DCCO system:
a. SNMP Traps
1) The DCCO software server shall be capable of sending SNMP traps to a third-party software monitoring tool (supplied by Contractor).
(a) Contractor-supplied third-party software monitoring tools shall be reviewed & approved by VA DCIE and VA OIT prior to purchasing & implementation.
2) The Contractor shall be responsible for configuring third-party software monitoring tool to raise alarms or send alerts based on the data contained in the traps.
3) Trap functionality shall use the SNMPv3 communication protocol.
b. SNMP Polling
1) The DCCO software server shall be capable of allowing SNMP polling by a third-party software polling tool (supplied by Contractor).
(a) Contractor-supplied third-party software monitoring tools shall be reviewed & approved by VA DCIE and VA OIT prior to purchasing & implementation.

2) The Contractor shall be responsible for configuring third-party software polling tool to raise alarms or send alerts based on the data it retrieves.
3) Polling functionality shall use the SNMPv2c communication protocol.

G. Security
1. Authentication and Encryption
a. Connection from the server to the network managers shall use a limited number of well-known TCP and UDP ports. This communication shall be SSL encrypted.
1) If desired by the customer, communication between server and client shall be encrypted with HTTPS using SSL.
(a) User account passwords shall not be directly stored. The DCCO system software shall use RFC 5802 (Salted Challenge Response Authentication Mechanism (SCRAM)) with SHA-256 for the hash algorithm.
(b) Passwords shall have configurable complexity and length requirements.
(c) The password policy shall be set to the customer's requirements during on-site commissioning.
2) Operating System
(a) The DCCO vendor shall ensure system security by restricting access to the server operating system. System users cannot access the server operating system.
(b) Operating system and DCCO software security updates shall be available to customers with a maintenance subscription in good standing.
3) Wireless Network
(a) Wireless mesh network data in operation shall use 128-bit AES-based encryption with multiple keys that are randomly generated and not readable.

(b) The wireless network shall employ time synchronized channel hopping and time diversity to ensure that control commands and telemetry sent between system components cannot be accessed or tampered with by any third party.

H. Fail-safes

1. The DCCO system shall employ multiple redundant fail-safes to maintain data center cooling and prevent overheating in the event of software failure, hardware failure, or other problems.
2. Software Fail-safes
   a. The DCCO system shall include three software-based fail-safe features. They are:
   b. Guard Mode – This software fail-safe shall automatically provide accelerated cooling in response to rising air temperatures in the data center.
   c. Dead Sensor Fail-safe – This software feature shall automatically monitor the number of wireless sensors which have lost communication with the DCCO control software. When the percentage of unreachable sensors reaches a preconfigured threshold, the system shall provide accelerated cooling until the problem is resolved.
   d. BACnet or Modbus Heartbeat – For facilities which use BACnet/IP or Modbus TCP communications protocol, a "heartbeat" signal shall be transmitted to the BMS on a user-defined schedule. If the heartbeat signal fails to arrive on time, the BMS shall raise an alarm and/or trigger a preconfigured response.
3. Hardware Fail-safe
   a. The DCCO system shall contain the following physical safeguard against control module loss of power or hardware failure: if a control module stops functioning, its fail-safe wiring will energize the relay to activate the cooling unit, and fan speed will be set by the cooling unit.
4. Firmware Fail-safe

a. The control module firmware fail-safe feature shall protect against failure in communication between the DCCO software and wireless control modules. In the absence of a regular signal from the control software, the firmware shall initiate a fail-safe response, turning the cooling unit on and setting fan speed to preconfigured max.

PART 3 - EXECUTION

3.1 SYSTEM PLANNING & REQUIREMENTS

A. Site Survey

1. To start the process of system planning and deployment, a survey of the customer's site shall be conducted in one of two ways:
   a. Email survey – The vendor shall email the customer a survey form requesting detailed information about the data center site, which the customer will fill out and return to vendor.
   b. Physical survey – An agent of the vendor shall visit the VA site to perform the survey in person to acquire the needed information.

B. Kick-off Meeting

1. Once the purchase order has been placed, the vendor will plan the deployment process in consultation with the customer. A kick-off meeting shall occur to develop a project plan and provide project requirements and submittals to the customer.

C. Progress Meetings

1. Vendor shall have regular progress meetings with customer and any third-party contractors involved with the project.

D. Requirements

1. Virtual Server Requirements
   a. This section specifies the environment and resources that support acceptable performance for the DCCO server software appliance running in a VMware environment.
   b. Responsibilities
      1) VA OIT shall provide the VMware environment.
      2) Vendor shall provide the DCCO software .OVA file.
   c. VMware Version

1) DCCO system VMs shall be created in the following VMware environment:
   (a) ESXi Version: 5.5. or later
   (b) VM Version: 10

d. The provided VMware .OVA file shall have the following properties:
   1) VMware Tools: Not Installed
      (a) Guest OS: Ubuntu Linux (64-bit)

e. Virtual Hardware
   1) The provided VMware .OVA file shall be configured with these settings:
      (a) CPU
         (1) vCPUs: 4
         (2) Cores per socket: 1
         (3) CPU Reserve Required: 0
      (b) Memory
         (1) Memory (RAM): 12 GB
         (2) Reserved Memory (RAM): 2 GB
      (c) Hard disk
         (1) Provisioned space: 1,024 GB
         (2) Storage: 1 TB
         (3) Provisioning Type: Thin

f. Requirements & Recommendations
   1) Vendor shall not support running VMware on any host that is not on the VMware compatibility list: http://www.vmware.com/guides
      (a) NTP shall be configured and operational to prevent “time drift” between the ESX host and the virtual machine.

2. Hardware Installation Requirements
   a. Rack temperature sensor installation requirements
      1) Sensors shall be installed in accordance with the vendor’s recommendations.
         (a) Sensors shall be installed where shown on the drawings.

(b) Sensors shall be attached to the cabinet frame. No sensors shall be attached to the cabinet door.
(c) Wire assemblies shall be neatly run and clipped in place.

3. Network Communication Requirements
   a. Server Network Connectivity Requirements
      1) One 10/100/1000Base-T Ethernet port with RJ45 connector, providing access to the LAN with logical connectivity to associated network managers.
         (a) Physical assignment of network ports and patching to designated equipment.
         (b) Static IPv4 address assignment for the DCCO server, including relevant subnet mask and default gateway, where appropriate.
      2) Network Manager Connectivity Requirements
         (a) One 10/100Base-T Ethernet port with RJ45 connector, providing access to the LAN with logical connectivity to the DCCO server.
         (b) Physical assignment of network ports and patching to designated equipment.
         (c) Static IPv4 address assignment for the network manager, including relevant subnet mask and default gateway, where appropriate.

3.2 VA PROVIDED INFORMATION

A. The VA shall provide the following information to facilitate installation and configuration of the system:
   1. Completed site survey form
      a. Number and type of cooling units
         1) Number of active IT racks
            (a) Total facility IT load
            (b) Network infrastructure information
            (c) Available communication protocols
            (d) Electricity rate at site
            (e) PUE of site
            (f) Chilled water plant data

2. Completed IP address form
    a. Server information, including:
        1) IPv4 address
            (a) Port assignment
            (b) Subnet mask
            (c) Default gateway
    b. Network manager information, including:
        1) IPv4 address
            (a) Port assignment
            (b) Subnet mask
            (c) Default gateway
3. Floorplans
    a. White space floorplan image files showing current rack locations in every room or floor to be controlled by the DCCO system.
4. Implementation of Networking and Installation Requirements
    a. Power run to server location
    b. Networking run to server location
    c. Power run to network manager locations(s)
    d. Networking run to network manager location(s)
5. Digital Communication Settings
    a. Modbus settings form
    b. BACnet settings form
    c. Wireless settings form
    d. SNMP settings form

3.3 VENDOR RESPONSIBILITIES

A. The vendor shall fulfill the following responsibilities:
    1. Identify a single point of coordination between vendor and customer staff for the project.
    2. Build model of projected energy savings based on physical details of the facility.
    3. Provide high-level system parts list to support pre-sales activity and estimate of customer benefits.
    4. Confirm details of project implementation, including specific placement of all DCCO system components.

5. Develop wiring diagrams for integration of control modules with local cooling equipment.
6. If needed, retain (or work with customer to retain) and supervise a customer-approved electrical contractor who will physically install required DCCO system equipment.
7. Oversee and verify the physical installation of rack sensors, network managers, and control modules throughout the critical facility.
8. Provide and communicate project updates to keep all parties informed of progress and items at risk to schedule.
9. Configure and commission the DCCO system, including system testing, fail-safe testing, baseline data capture, activation of system control, and operational validation.
10. Train local staff in the use and operation of the DCCO system.
11. Confirm customer acceptance at project conclusion.
12. Prepare and present DCCO system reports to document deployment details and DCCO system performance.
13. Vendor shall configure the system hardware as required, then ship it to the customer site when ready.
14. The vendor shall continually monitor the field installation for code compliance and quality of workmanship.

3.4 INSTALLATION/DEPLOYMENT

A. Protection
   1. The DCCO vendor shall protect all work and material from damage by its employees and/or subcontractors, and shall be liable for any damage thus caused.
   2. The vendor shall be responsible for its work and equipment until finally inspected, tested, and accepted.

B. Pre-Installation Conference
   1. Prior to the start of the installation, the DCCO vendor shall meet with customer to review the networking requirements, hardware layout, installation procedures, and coordination with other trades.

C. Installation

1. The vendor shall step through the following process to install DCCO system in customer’s site:
2. Unpack and sort materials
3. Install DCCO software server
4. Install wireless network manager(s)
5. Install wireless rack temperature sensors
6. Install cooling unit control modules
7. Configure hardware devices in DCCO software
8. Test actuate cooling units
9. Validate cooling unit power reporting via amp clamp
10. Validate sensor monitoring
11. Final configuration
12. Start recording baseline sensor data

D. Workmanship
1. Equipment and wiring/raceway shall be installed parallel to building lines (i.e., horizontal, vertical, and parallel to walls) wherever possible.
2. The integrity of all wiring shall be verified to ensure continuity and freedom from shorts and grounds.
3. All equipment, installation, and wiring shall comply with applicable industry specifications and standards for performance, reliability, and compatibility; and be executed in strict adherence to local codes and standard practices.

E. Cleaning
1. The Contractor shall clean up all debris resulting from their installation activities. The vendor shall remove all cartons, containers, crates, etc., under their control as soon as their contents have been removed. Waste shall be collected and placed in a designated location.
2. The Contractor shall clean all work, equipment, etc., keeping it free from dust, dirt, and debris, etc.

F. Regulatory Requirements:
1. The DCCO system, vendor, and contractors shall comply with all applicable federal, state, and local laws, codes, ordinances, and regulations.

2. Any necessary approvals from these authorities shall be obtained by the Contractor.

3.5 STARTUP AND TESTING

A. Once installation is complete, the commissioning process shall bring the DCCO system online in phases. Vendor shall execute the following in coordination with customer:
   1. Cooling unit adjustment
   2. Airflow remediation
   3. Activation of DCCO system control software
   4. Testing of system fail-safe behaviors

B. Prior to acceptance, the DCCO system shall undergo a series of performance tests to verify operation and compliance with this specification.

C. The tests described in this section shall be performed in addition to the tests that the vendor performs as a necessary part of the installation, start-up, and debugging.

D. The customer shall be present to observe and review these tests.

E. The tests shall demonstrate:
   1. Compliance with rack temperature limits.
   2. Monitoring of cooling energy usage.
   3. Efficacy of fail-safes.
   4. Operation of user interface.

F. Any discrepancies between the specification and actual performance will be rectified and re-tested.

G. The vendor shall be responsible for any necessary repairs or revisions to the hardware or software to successfully complete all tests.

H. Customer Acceptance
   1. When the customer is satisfied with the demonstration, the customer shall sign the acceptance form.
   2. Vendor shall create and deliver completion report to customer with summary of system configuration and performance.

3.6 MAINTENANCE PLAN

A. A maintenance plan shall be provided under this contract for the DCCO system to include technical support and software updates from the Vendor for an initial period of 1 year.

B. Vendor support provided with maintenance plan shall include email or phone support from qualified DCCO system technical staff, regular software maintenance including patch deployment, and on-request webinar training for system operators.

3.7 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS and Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and as required by the System Readiness Checklist provided by the Commissioning Agent.

B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS and Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

3.8 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer’s technical representative for 16 hours to instruct VA personnel in operation and maintenance of system.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS and Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

C. The vendor shall provide instruction to designated customer personnel about the adjustment, operation, and maintenance of the DCCO system. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. The training shall include:

1. DCCO system overview
2. DCCO system architecture
3. DCCO system basic concepts
4. Navigation through the system console

5. Changing rack temperature set points
6. Overriding cooling unit control
7. Understanding system alarms
8. Viewing collected and calculated trend data
9. Adding and removing rack temperature sensors
10. Best practices

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SECTION 23 10 00
FACILITY FUEL OIL SYSTEMS

PART 1 GENERAL

1.1 DESCRIPTION

A. Diesel fuel oil and unheated burner fuel oil tanks, piping, and accessories located outside, underground or aboveground as shown on contract drawings. Refer to contract drawings for type of fuel and for tank capacities.

B. Tank fluid level monitoring and alarm systems.

C. Leak detection system for tanks and underground piping.

D. Fuel oil quality maintenance system (water and particulate removal).

E. A complete listing of common acronyms and abbreviations are included in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

C. Section 01 81 11, SUSTAINABLE CONSTRUCTION REQUIREMENTS.

D. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

E. Section 03 30 00, CAST-IN-PLACE CONCRETE.

F. Section 05 50 00, METAL FABRICATIONS.

G. Section 09 91 14, EXTERIOR PAINTING.

H. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

I. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

J. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

K. Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION.

1.3 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Where conflicts occur these specifications and the VHA standard will govern.

B. American Petroleum Institute (API):

1. RP 1631-2001 Interior Lining and Periodic Inspection of Underground Storage Tanks

C. American Society of Mechanical Engineers (ASME):
   1. B16.5-2017 Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard.
   2. B16.9-2018 Factory Made Wrought Buttwelding Fittings
   3. B16.11-2016 Forged Fittings, Socket-Welding and Threaded
   4. B31.1-2018 Power Piping
D. American Society for Testing and Materials (ASTM):
   1. A36/A36M-2017 Standard Specification for Carbon Structural Steel
   2. A53/A53M-2018 Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
   3. A105/A105M-2014 Standard Specification for Carbon Steel Forgings for Piping Applications
   4. A106/A106M-2015 Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
   5. A126-04(R2019) Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
   6. A234/A234M-2015 Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
   7. B62-2017 Standard Specification for Composition Bronze or Ounce Metal Castings
   8. D2996-2015 Standard Specification for Filament-Wound '' Fiberglass'' (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe
E. Federal Specifications (Fed. Spec.):
   1. A-A-60005-1998 Frames, Covers, Grating, Steps, Sump and Catch Basin, Manhole
F. NACE International (NACE):
   1. SP0169-2013 Control of External Corrosion on Underground or Submerged Metallic Piping Systems
   2. 3/SSPC- SP6-2013 Commercial Blast Cleaning
   3. 4/SSPC-SP7-2006 Brush-off Blast Cleaning
G. National Electrical Manufacturers Association (NEMA):
   1. 250-2014 Enclosures for Electrical Equipment (1000 Volts Maximum)
H. National Fire Protection Association (NFPA):
   1. 30-2021 Flammable and Combustible Liquids Code

2. 31-2020 Standard for the Installation of Oil-Burning Equipment
3. 70-2021 National Electrical Code (NEC)

I. Steel Tank Institute (STI):
1. F001-2017 Flameshield\'ae Standard for Fire Tested Tanks
2. F841-2010 Standard for Dual Wall Underground Steel Storage Tanks
3. F894-2018 ACT-100\'ae Specification for External Corrosion Protection of FRP Composite Steel Underground Storage Tanks
4. F941-2015 Fireguard: Specification for Fireguard Protected Aboveground Storage Tanks
5. F961-2017 ACT-100U Specification for External Corrosion Protection of Composite Steel Underground Storage Tanks
6. P3-2015 Specification and Manual for External Corrosion Protection of Underground Steel Storage Tanks
7. R891-2006 Recommended Practice for Hold Down Strap Isolation

J. Underwriters Laboratories Inc. (UL):
1. 58-2018 Standard for Steel Underground Tanks for Flammable and Combustible Liquids
2. 142-2019 Standard for Steel Aboveground Tanks for Flammable and Combustible Liquids
3. 971-2019 Standard for Nonmetallic Underground Piping for Flammable Liquids
4. 1316-2018 Glass-Fiber-Reinforced Plastic Underground Storage Tanks for Petroleum Products, Alcohols, and Alcohol-Gasoline Mixtures
5. 1746-2007(R2014) Standard for External Corrosion Protection Systems for Steel Underground Storage Tanks
6. 2085-2019 Standard for Protected Aboveground Tanks for Flammable and Combustible Liquids

1.4 SUBMITTALS

A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Information and material submitted under this section shall be marked “SUBMITTED UNDER SECTION 23 10 00, FACILITY FUEL OIL SYSTEMS”, with applicable paragraph identification.

C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.

D. Underground Tanks:

1. Drawings of tanks, anchoring devices, heating coils (if required), tank manholes, tank manhole enclosures, access doors for the tank manhole enclosures and all accessories. Include overall dimensions and dimensional locations and sizes of all anchoring devices, pipe connections, and access openings.
2. Manufacturer's installation instructions describing recommended foundation, bedding and backfill material, support and anchoring devices, and method of installation.
3. Weight of entire tank assemblies, empty and flooded.
4. Certification of compliance with specified standards.
5. Certification that steel tank manufacturer participates in the Steel Tank Institute (STI) Quality Assurance Program.
6. Data certifying that tanks are designed for surcharge loads of backfill, traffic and other construction.
7. Design and construction of tanks, secondary containment, pipe connections, manholes, anchoring devices, access doors for tank manhole enclosures.
8. Application and performance data on tank coating (steel tanks) from manufacturer of coating.
9. Design of cathodic protection system (when specified) for steel tanks.

E. Aboveground Steel Tanks, Including Vault-type Tanks:

1. Drawings of tanks, supports, ladders, platforms, heating coils, tank manholes, emergency relief vents and all accessories. Include overall dimensions and dimensional locations and sizes of pipe connections, and access openings.
2. Recommended tank support locations.
3. Weight of entire tank assembly, empty and flooded.
4. Design and construction of primary tanks, insulation, secondary containment, supports, pipe connections, platforms.

5. Application and performance data on coatings from manufacturer of coatings.
6. Data certifying tanks are designed for surcharge loads of platforms shown.
7. Certification of compliance with specified standards.
8. Certification that steel tank manufacturer participates in Steel Tank Institute (STI) Quality Assurance Program.
9. Design, construction, performance, dimensions of emergency relief vents.
10. Seismic Data: Refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

F. Fuel Piping:
1. ASTM and UL compliance.
2. Grade, class or type, schedule number.
3. Manufacturer.

G. Pipe Fittings, Unions, Flanges:
1. ASTM and UL compliance.
2. ASTM standards number.
3. Catalog cuts.
4. Pressure and temperature rating.

H. Foot Valves, Check Valves, Overfill Prevention Valves:
1. Catalog cuts showing design and construction.
2. Pressure and temperature ratings.
3. Pressure loss and flow rate data.
4. Materials of construction.
5. Accessories.

I. Secondary Containment System for Fuel Piping:
1. Sizes, materials, construction of containment system including end seals, sumps, coatings and pipe supports.
2. Layout of system.
3. Installation instructions.
4. Design of cathodic protection system (steel casing).

J. Leak Detection System:
1. Drawings, description and performance data on sensors, control units.

2. Description of operation.
3. Layout of system.
4. Installation and operating instructions.
5. Data on interconnecting wiring systems to be furnished.

K. Tank Fluid Level Monitoring Instrumentation System:
1. Drawings showing instruments and in-tank sensing units, with dimensions.
2. Design and construction of all elements of system.
3. Installation instructions.

L. Tank and Piping Accessories: Design, construction, and dimensions of vent caps, fill boxes, fill caps, spill containers and other accessories.

M. Fuel Quality Maintenance System:
1. Drawings and description of all components and arrangement of system.
2. Design and performance of pumps, filters.
3. Catalog data and operation of control system.
4. Installation instructions.

N. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replacement parts, and troubleshooting guide:
1. Include complete list indicating all components of the systems.
2. Include complete diagrams of the internal wiring for each item of equipment.
3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

O. Completed System Readiness Checklist provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

P. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

1.5 QUALITY ASSURANCE

A. Approval by Contracting Officer is required of products or services of proposed manufacturers, suppliers and installers, and will be based on Contractor’s certification that:
   1. Manufacturers regularly and currently manufacture tanks, tank and piping accessories, tank fluid level monitoring and leak detection systems, and fuel quality management systems.
   2. Manufacturers of steel tanks participate in the Quality Assurance Program of the Steel Tank Institute (STI).
   3. The design and size of each item of equipment provided for this project is of current production and has been in satisfactory operation on at least three installations for approximately three years. Current models of fluid level and leak detection systems with less than three years’ service experience are acceptable if similar previous models from the same manufacturer have at least three years’ service experience.

B. Apply and install materials, equipment and specialties in accordance with manufacturer' s written instructions. Conflicts between the manufacturer' s instructions and the contract drawings and specifications shall be referred to the COR for resolution. Provide copies of installation instructions to the COR two weeks prior to commencing installation of any item.

C. All equipment shall be free from defects that would adversely affect the performance, maintainability and appearance of individual components or overall assembly.

D. Tanks, Secondary Containment Systems for Piping, Plastic Piping and Containment Systems, Tank Level Monitoring Systems, Leak Detection Systems, Fuel Quality Management Systems, Cathodic Protection Systems: Authorized manufacturer’s representatives shall provide onsite training of installers and supervision of the installation and testing of the equipment and systems to assure conformance to written instructions of manufacturers.

E. Tank and piping installation contractor shall be certified as acceptable by local and state pollution control authorities.

F. Entire installation shall conform to requirements of local and state pollution control authorities.

G. Pipe Welding: Conform to requirements of ASME B31.1. Welders shall show evidence of qualification. Welders shall utilize a stamp to identify their work. Unqualified personnel will be rejected.

H. Assembly of Glass Fiber Reinforced Plastic Piping: Installation personnel shall have been trained, tested and certified under a procedure approved by the manufacturer of the piping. Proof of certification, in writing, shall be provided to the COR.

I. Where specified codes or standards conflict, consult the COR.

J. Label of Conformance (definition): Labels of accredited testing laboratories showing conformance to the standards specified.

K. Equipment and materials installed shall be compatible in all respects with other items being furnished and with existing items so that the result will be a safe, complete and fully operational system which conforms to contract requirements and in which no item is subject to conditions beyond its design capabilities.

1.6 AS-BUILT DOCUMENTATION

A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

B. Certification documentation shall be provided to COR 21 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and provide documentation/certification that all results of tests were within limits specified. Test results shall contain written sequence of test procedure with written test results annotated at each step along with the expected outcome or setpoint. The results shall include all readings, including but not limited to data on device (make, model and performance characteristics), normal pressures, switch ranges, trip points, amp readings, and calibration data to include equipment serial numbers or individual identifications, etc.

1.7 PERMITS

A. Contractor shall obtain and complete all tank permit and registration forms required by governmental authorities.

PART 2 PRODUCTS

2.1 ABOVEGROUND CONCRETE-INSULATED STEEL VAULT TANKS

A. Type: All-welded steel tank, horizontal cylindrical or rectangular configuration, atmospheric pressure, concrete insulation, double-containment, for aboveground installation as shown. Entire unit factory-fabricated, including steel tank and concrete insulation. Provide tank supports that can be anchored to a concrete foundation.

B. Construction:

1. Comply with UL 2085 for protected tanks, vehicle impact resistant and projectile resistant with secondary containment. Provide label of conformance.
2. Inner tank ASTM A36/A36M steel constructed in conformance with UL 142. Provide label of conformance. Steel tanks shall be supported as recommended by steel tank manufacturer. Top of secondary tank shall be sloped to shed rainwater. Test tanks for leaks with test pressure of 21 to 34 kPa (3 to 5 psig) gauge. Furnish certificate that inner and outer tanks have been tested and are leak-free and pressure-tight.
3. Concrete Insulation:
   a. Shall consist of 20 MPa (3,000 psig) minimum concrete.
   b. Shall be structurally designed to support the filled tank and a top live load of 4.8 kPa (100 lb./sq. ft.).
   c. Monolithic pour with no cold joints, heat sinks. As an alternate, there may be one continuous shiplap joint located at horizontal center of vault sealed with fire and fuel resistant gaskets.
   d. Construct in accordance with ACI and AASHTO standards including concrete placement, vibration, and quality assurance.
4. Conform to NFPA 30 or NFPA 31 fire safety standards as applicable. Design for two-hour fire exposure. Provide fittings for grounding per NFPA 70.

5. The tank assembly shall have capability of physical monitoring for leaks between primary and secondary containment.
6. Provide overfill containment (spill container) with internal drain and positive seal.

C. Factory Cleaning: Clean interior and exterior. Remove mill scale, dirt, rust, oil, welding debris, loose coatings and coatings incompatible with fuel stored or protective coating.

D. Factory Coatings: Provide coating of rust resistant red oxide primer on non-fuel side of steel tanks. For tanks with interior access, coat interior of primary tank from bottom to 1 m (3 feet) above bottom in conformance with API RP 1631. Provide two coats of fuel resistant epoxy coating on exposed surfaces of the external concrete tank.

E. Platforms, Ladders, Stairs, Handrails: Provide as shown. Shall be welded steel assemblies conforming to OSHA requirements. Paint in accordance with Section 09 91 00, PAINTING. Galvanizing is an acceptable alternative.

F. Pipe Connections to Tanks:
1. Pipe shall terminate 75 mm (3 inches) minimum from top of unit.
2. Conform to UL 142.
3. Pipe sizes 50 mm (2 inches) and smaller, threaded. Pipe sizes 65 mm (2-1/2 inches) and larger, 1034 kPa (150 psig) ASME flanged.
4. Welded joints required on steel piping located inside tanks.
5. Provide and coordinate tank connection quantities, sizes and types with requirements of tank level gauge unit; leak detector sensor; sounding rod; vent, fill, supply and return pipes; and other pipes as shown.
6. Provide valved drain on interstitial space.

G. Tank Manholes: Provide quantity and size shown. Bolted cover type, gasketed.

H. Emergency Relief Vents for Fire Exposure: Venting capacity shall conform to NFPA 30 or NFPA 31 as applicable. Provide separate vents for primary and secondary tanks. Standard product of a manufacturer, designed to automatically open at tank pressure of 17 kPa (2.5 psig). Aluminum or cast-iron construction, with Teflon-coated seating surface.

I. Internal Ladder: Provide as shown with 50 mm x 6 mm (2 inch x 1/4 inch) sides and 20 mm (3/4 inch) diameter rungs at 300 mm (12 inches) on center. Provide slide supports to allow for tank movement.

J. Wear (Striker) Plates: Provide 300 mm (12 inch) square, 6 mm (1/4 inch) thick steel plates welded to tank bottom directly under the sounding opening, the fuel return discharge, and the fill discharge.

K. Lifting Lugs: Provide for rigging tanks.

L. Seismic Design: Refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

2.2 SOIL SEPARATOR MAT

A. Material: Porous, non-woven polypropylene geotextile, Weight: 135 g per sq. meter (4 ounces per square yard), resistant to all alkalies and weak acids.

2.3 BTANK AND PIPING ACCESSORIES

A. Vent Caps: Galvanized cast iron or cast aluminum with brass or bronze screens, arranged to permit full venting and to prevent entry of foreign material into the vent line. Same pipe size as vent pipe.

B. Fill Boxes:

1. Spill-container type enclosing a fill cap assembly with camlock hose connector with closure coordinated with fittings used by fuel supplier.
2. Watertight assembly, cylindrical body, quick-opening corrosion-resistant watertight sealable cover, polyethylene spill containment compartment with minimum 5 gallon capacity. Integral drain valve with discharge to fill pipe.
3. Fill cap shall be lockable, tight-fill design with provision for padlock on the top of the cap. Fill cap shall screw onto threaded adapter that can be removed without removing fill box. Entire assembly shall seal tight with no leakage during filling and when cap is in place.
4. Provide special tools necessary for opening fill boxes and fill caps.

5. Protect spill container from traffic by ramped, drain-slotted cast iron body ring and cover. Design shall prevent transmission of traffic loads to the underground tank. Spill-container type not required at locations designated only for sounding tanks.

C. Fill caps located above grade without fill boxes shall be lockable, tight-fill design, operated by special wrench that shall be furnished. Entire assembly shall seal tight with no leakage during fill and when cap is in place.

D. Support horizontal portion of pipes located inside tank every 2100 mm (7 feet) maximum.

E. Furnish gauging chart, liters versus mm and gallons versus inches depth.

F. Furnish sounding rod for each tank size. Mark rods in increments representing five percent of tank capacity. Provide length of rod suitable for tank burial depth (if applicable). Rods shall be graduated in gallons.

G. Fill Point Identification:

1. Fill Boxes at Grade Level: Aluminum, brass or bronze plate, anchored to concrete fill box pad with stamped or engraved letters 20 mm (3/4 inch) high.
2. Fill Caps above Grade: Aluminum, brass or bronze plate, clamped to fill pipe, with stamped or engraved letters 20 mm (3/4 inch) high.
3. Legend: "BURNER FUEL OIL FILL" "DIESEL FUEL FILL" or "SOUNDING" as appropriate.

2.4 PIPING, VALVES, FITTINGS

A. Fuel supply and return, tank fill, vents, sounding, and pump out.

B. Steel Pipe and Fittings:

1. Piping: Steel, seamless or electric resistance welded (ERW), ASTM A53/A53M Grade B or ASTM A106/A106M Grade B, Schedule 40.
   a. Aboveground piping shall be painted. Refer to Section 09 91 00, PAINTING.
2. Joints: Socket or butt-welded. Threaded joints are prohibited except at valves, unions and tank connections.
3. Fittings:

a. Butt-welded joints: Steel, ASTM A234/A234M, Grade B, ASME B16.9, same schedule as adjoining pipe.
b. Socket-welded joints: Forged steel, ASME B16.11, 13,790 kPa (2000 psig) class.

4. Unions: Malleable iron, 2070 kPa (300 psig) class.
5. Companion flanges: Flanges and bolting, ASME B16.5.
6. Welding flanges: Weld neck, ASME B16.5, forged steel ASTM A105/A105M, 1034 kPa (150 psig).

C. Check Valves - Fuel Pump Suction.
1. Pipe Sizes 50 mm (2 inches) and under: Rated for 1375 kPa (200 psig) water-oil-gas, swing-type, threaded ends, ASTM B62 bronze body. Provide union adjacent to valve.

D. Foot Valves - Fuel Pump Suction: Double poppet, lapped-in metal-to-metal seats, double-guided stems, 20 mesh inlet screen, same size as fuel suction piping. Foot valve shall be removable to above grade through the tank manhole enclosure or through extractor fitting.

E. Extractor Fittings: Arranged to permit removal of foot valves, overfill prevention valves, and other devices that are located below grade. Access point shall be through a cast iron fill box-type manhole located at grade. Provide extractor wrench.

F. Overfill Prevention Valve: Aluminum automatic valve designed for underground or aboveground tanks, as applicable. Removable through the extractor fitting on underground tanks. Locate valve near the top of the tank in the fill pipe. On underground tanks with gravity fill, provide two stage automatic float-operated valve. First stage operation at 92 percent tank capacity shall reduce flow to 0.3 L/s (5 gpm) or less. Second stage operation shall stop flow completely when tank is no more than 95 percent full. On aboveground tanks, or tanks pressure-filled, provide single stage valve, rated for fill flow and pressure, which stops flow completely at 95 percent of tank capacity. Valve shall include method for draining oil trapped above the valve into the tank.

2.5 LEAK DETECTION SYSTEMS

A. Automatic digital continuous monitoring systems responsive to the presence of water and hydrocarbons in the interstitial space of the double-wall tanks, in the tank manhole access enclosures, and in the secondary containment of fuel piping systems. System shall distinguish between hydrocarbon and water and identify location of leak as to individual tank and piping system. System may be combined with tank fluid level monitor and alarm system specified in paragraph, TANK FLUID LEVEL MONITOR AND ALARM SYSTEM.

B. Functions and Arrangement:
   1. Single control station to monitor all sensing probes.
   2. Visual indicator to monitor and identify leaks as water or hydrocarbon and location.
   3. Indicators showing system status including faults and alarms.
   4. On board printer that provides complete reports of all system functions upon command.
   5. Panel circuit test button.
   6. 95 dB audible alarm with silencing control to sound when leak is detected.
   7. Eight-hour memory backup system with battery.
   8. NEMA 250 Type 4 cabinet.
   9. UL or other accredited testing laboratory listing.
   10. Modbus or BACNet communications to DDC system to indicate system in service and alarm conditions.

C. Sensors:
   1. Designed for required locations including: Insertion between walls of double-wall tanks, in sumps in double-wall piping systems and in tank manhole enclosures. Sensing points shall be at lowest point of each tank or sump. Intrinsically safe design.
   2. Sensing units shall detect presence of water and a minimum 3.2 mm (1/8 inch) thick layer of hydrocarbon on surface of water and minimum 50 mm (2 inch) thickness of hydrocarbon in area that has no water present.

3. Sensors shall be arranged to allow replacement of individual sensors without disturbing other portions of leak detection system or fuel storage and piping system. Underground sensors shall be accessed through caps as grade.
4. Materials of construction shall be non-corroding.
5. Transmit status signal to control unit.

D. Components:

1. Provide manholes at grade for each sensor cap similar in construction to fill boxes. Manholes shall be cast iron, quick-opening cover, watertight, minimum size necessary to accommodate sensor caps. Provide identification plates, similar to those specified for fill points, labeled “MONITORING/OBSERVATION WELL-DO NOT FILL”. Provide special tools if necessary for opening covers.
2. Sensor housings from tank and piping to grade shall be Schedule 40 PVC, or stainless steel.
3. Underground wiring between probes and control unit: Place in water-tight corrosion-resistant conduit system conforming to Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION.

2.6 TANK FLUID LEVEL MONITOR AND ALARM SYSTEMS

A. Digital systems for central monitoring of fuel and water levels in all fuel oil storage tanks in the project. High and low level visual and audible alarms. Volumetric tank-tightness testing. Complete with all transducing, transmitting, and receiving devices. On board printer to provide complete report of all system functions upon command. System may be combined with leak detection system specified in paragraph, LEAK DETECTION SYSTEMS.

B. Fluid Level Monitor:

1. Digital continuous readout, showing tank oil and water levels in gallons, smallest reading one gallon. Provide identification of product measured, measuring units, and the tank number.
2. Tank and fuel characteristics contained in preprogrammed non-volatile field-replaceable databases. Protected power supply.

C. High and Low Fluid Level Alarm System:

1. Automatic continuous on-line monitoring of all tanks.

2. Visual and audible indicators combined with fluid level monitor. Identify the tank that is in alarm condition.
3. Manual alarm test and silencing controls.
4. Low level alarm actuation adjustable 0-25 percent of tank capacity. High level alarm actuation adjustable 75-100 percent of tank capacity.

D. Locate all indicators, selector switches, alarms on face of wall-mounted NEMA 250, Type 4 panel.

E. Remote Alarm Annunciator:
1. Visual and audible high-level alarms adjacent to tank fill box locations. Locate in NEMA 250 Type 4X weatherproof exterior wall or pole-mounted panels.
2. Alarm shall include flashing red light with 180-degree visibility for each tank and 95 dB horn or 100 mm (4 inch) diameter bell. Provide alarm silence control.
3. Provide identification sign: "WHEN ALARM SOUNDS - FUEL TANK FILLED TO CAPACITY - DO NOT OVERFILL".

F. Modbus or BACNet communication to DDC system to indicate tank fluid level and alarm conditions. Telephone modem communication capability.

G. System Performance: Accuracy plus or minus 2.5 mm (0.10 inch) of fluid height in inventory mode and 0.25 mm (0.01 inch) in leak detection mode. Automatic compensation for fluid temperature changes. Volumetric tank tightness sensitivity of 0.4 lph (0.1 gph).

H. Sensors:
1. Provide sensor types such as magnetostrictive, capacitance, float, hydrostatic and other types as necessary for the applications.
2. Apply in accordance with manufacturer’s instructions with provisions for easy future replacement without need for excavation.

3. Provide for each hydrostatic sensor a constant flow differential pressure regulator and transmitter protected from fuel contamination. Air supply shall include filter and over-pressure protection. Provide desiccant-type dryer on air supply designed for removal of water vapor. Dryer rating, minimum 4.6 L/s (10 SCFM). Provide moisture indicator. Dryer may be deleted if air supply source has a refrigerated dryer.
4. Float-type units shall be designed for installation and removal through a 100 mm (4 inch) diameter vertical pipe mounted in the top of the tank.

I. Underground Wiring and Piping: Enclose in water-tight corrosion-resistant conduit system sized and arranged as recommended by system manufacturer and conforming to Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION.

J. Code Conformance: NFPA 70.

2.7 FUEL OIL QUALITY MAINTENANCE SYSTEMS

A. Complete factory-assembled automatic particulate filtration and dewatering system to maintain the purity of No. 2 fuel oil in storage. The system shall circulate the oil from the storage tank, through the system, and back to the storage tank. Provide quantity and capacity of systems to serve tanks as shown, connected to the tank suction and return pipes. Smaller systems without large water storage tanks and without fuel additive injection shall be wall-mounted. Provide with digital controls.

B. Performance: Design for nearly 100 percent water removal. Provide 2-micron particulate filtration. Each system shall have capacity to turn over the largest connected full tank one time within 22 hours maximum. System shall be designed to allow continuous operation with brief interruptions to manually change filters and clean strainers.

C. Components:

1. Strainer: 100 mesh perforated stainless steel basket. Clamped covers. 861 kPa (125 psig) design pressure.

2. Water Separation Unit: Two stage, designed to reduce water content of fuel to less than 10 ppm. Centrifugal separator for removal of large droplets and renewable resin-impregnated cellulose water coalescing elements. Water removed shall flow to water holding sump in the unit. Water sensing probe to alert the operator when water level in bowl has reached capacity.
3. Filter: 2-micron filtration with 96 percent removal efficiency, valved manual drain. Replaceable elements.
4. Filtration Pump: Positive displacement base-mounted pump with cast iron or bronze housing, for circulating the oil from the storage tank, through the water separation and filter units and back to the storage tank. Pump shall have carbon bushings, stainless steel shaft and Teflon mechanical seal, ODP motor.
5. Controls:
   a. Digital PLC electronic controls for all system control and alarm functions. Relay logic not acceptable.
   b. Control panel with selector for modes of operation, indicators to show system status, and visual and audible alarms to signal the need for operator intervention. Operator interface shall be 2 x 20 LCD and keypad.
   c. Controls shall include:
      1) Control power “on-off”.
      2) “Cycle Start”.
      3) “Cycle Cancel”.
      4) “Hand-off-Auto” for filtration pump.
      5) Pump cycle timer set function.
      6) Cycle duration selector.
   d. Indications shall include:
      1) “Control Power On”.
      2) “Pump Run”.
      3) “Pump Failure”.
      4) “Excess Water in Fuel”.
      5) “Filter Water Level High”.
      6) “Rupture Basin Leak” alarm.
      7) “High Pressure Drop in Strainer” alarm.

8) "High Pressure Drop in Filters" alarm.

9) "High Pressure" alarm and automatic shutdown.

e. Filter and strainer differential pressure gauges, differential pressure switches and control. Provide indication when filters should be changed.

f. Over pressure switch and control to shut down pump if filter inlet pressure exceeds limits.

g. All primary wiring exiting the enclosure shall be encased in conduit.

h. Magnetic motor starters with overload protection.

i. Circuit breakers.

j. Control enclosure shall be NEMA 4, fully gasketed doors with 3 point lockable latching. Interior shall have white gloss finish; exterior shall be chemical-resistant gray enamel. All controls and indicating devices shall be mounted on front of enclosure and labeled with black Phenolic labels with white lettering.

D. Enclosure – Wall Mounted Units: 14-gauge steel, NEMA Type 4 enclosure, continuously welded, framed cabinet. Provide doors for complete access to all equipment. Doors shall have a turned edge, piano hinges, three-point locking mechanisms. Corrosion-resistant prime and finish coatings on all interior and exterior surfaces.

E. Water Drainage System: Sealed bowl (bottle) with high level alarm system. Water collected in filters shall drain to a sealed bowl that can be easily removed and emptied.

2.8 CONCRETE FOUNDATIONS

A. Concrete pads for aboveground tanks are specified under Section 03 30 00, CAST-IN-PLACE CONCRETE.

PART 3 EXECUTION

3.1 GENERAL

A. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no additional cost or time to the Government.

3.2 INSTALLATION AND TESTING, ABOVEGROUND TANKS

A. Conform to NFPA 30 or NFPA 31 as applicable.

B. Support tanks on steel saddles welded to the tanks. Anchor to concrete foundations. Provide molded neoprene isolation pads between the steel supports and the concrete foundation.

C. After tanks are installed, test steel tanks with air pressure of 21 kPa to 34 kPa (3 to 5 psig), using soapsuds to locate leaks. Repair leaks by chipping to bare metal and rewelding. Retest until all leaks are repaired. Repair all damaged areas of prime coat on tanks and steel dikes (if furnished). Test interstitial area between steel tank walls with air at pressure recommended by tank manufacturer. Tests shall be witnessed by the COR.

D. Provide electrical grounding in accordance with NFPA 70.

3.3 INSTALLATION AND TESTING, LEAK DETECTOR SYSTEMS FOR TANKS AND PIPING

A. Wiring shall conform to NFPA 70.

B. Locate control monitor panels 1500 mm (5 feet) above the floor on inside wall of boiler room, generator room or garage, depending on type of fuel tank served, unless shown otherwise.

C. Test operation of each probe, and monitoring system with fuel and water. If type of probe utilized is damaged by exposure to fuel, provide temporary probe for testing monitoring system.

3.4 INSTALLATION, TANK FLUID LEVEL INDICATOR AND ALARM SYSTEM

A. Wiring shall conform to NFPA 70.

B. Locate level indicator and alarm panel 1500 mm (5 feet) above the floor on inside wall of boiler room, generator room or garage, depending on type of fuel tank served, unless shown otherwise.

C. Locate remote high-level alarm on exterior wall or pole in view of tank fill point, 2400 mm (8 feet) above grade.

3.5 INSTALLATION, FUEL OIL QUALITY MAINTENANCE SYSTEMS

A. Locate systems within easy reach of persons standing on floor, with sufficient elevation to allow gravity flow of water from system to water storage tank sitting on the floor.

B. Connect to tank suction and return piping systems with isolation valves. Provide compound pressure gauges at suction and discharge piping connections. Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT for gauge requirements.

3.6 STARTUP AND TESTING

A. Perform tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.

B. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.

C. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with COR and Commissioning Agent. Provide a minimum notice of 10 working days prior to startup and testing.

3.7 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

B. Components provided under this section of the specification will be tested as part of a larger system.

3.8 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer' s technical representative for 8 hours to instruct each VA personnel responsible in operation and maintenance of the system.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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SECTION 23 21 13
HYDRONIC PIPING

PART 1 GENERAL

1.1 DESCRIPTION

A. Water piping to connect HVAC equipment, including the following:
   1. Drain piping for hydronic systems.
   2. Extension of domestic water make-up piping for HVAC systems.
   3. Hydronic system water piping.

B. Hydronic system components, including the following:
   1. Valves.
   2. Pressure & temperature gauges.

C. A complete listing of common acronyms and abbreviations are included in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.
B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.
D. Section 07 84 00, JOINT FIRESTOPPING.
E. Section 07 84 13, PENETRATION FIRESTOPPING.
F. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.
G. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
H. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
I. Section 23 07 11, HVAC AND BOILER PLANT INSULATION.
J. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
K. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
L. Section 23 25 00, HVAC WATER TREATMENT.

1.3 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Where conflicts occur these specifications and the VHA standard will govern.

B. American Society of Mechanical Engineers (ASME):

1. B1.20.1-2013 Pipe Threads, General Purpose (Inch)
2. B16.3-2016 Malleable Iron Threaded Fittings: Classes 150 and 300
3. B16.4-2016 Gray Iron Threaded Fittings: (Classes 125 and 250)
4. B16.5-2020 Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard
5. B16.9-2018 Factory Made Wrought Buttwelding Fittings
6. B16.11-2016 Forged Fittings, Socket-Welding and Threaded
7. B16.18-2018 Cast Copper Alloy Solder Joint Pressure Fittings
8. B16.22-2018 Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings
9. B16.24-2016 Cast Copper Alloy Pipe Flanges and Flanged Fittings: Classes 150, 300, 600, 900, 1500, and 2500
10. B16.39-2019 Malleable Iron Threaded Pipe Unions: Classes 150, 250, and 300
11. B16.42-2016 Ductile Iron Pipe Flanges and Flanged Fittings
12. B31.9-2020 Building Services Piping
13. B40.100-2013 Pressure Gauges and Gauge Attachments
14. ASME Boiler and Pressure Vessel Code (BPVC):
    a. BPVC Section VIII-2021 Rules for Construction of Pressure Vessels, Division 1

C. American Society for Testing and Materials (ASTM):
1. A47/A47M-1999 (R2018e1) Standard Specification for Ferritic Malleable Iron Castings
2. A53/A53M-2020 Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
3. A106/A106M-2019a Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
4. A126-2004 (R2019) Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
5. A183-2020 Standard Specification for Carbon Steel Track Bolts and Nuts
6. A193-2024 Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications

7. A216/A216M-2021 Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service
8. A307-2021 Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 PSI Tensile Strength
9. A536-1984 (R2019e1) Standard Specification for Ductile Iron Castings
10. B62-2017 Standard Specification for Composition Bronze or Ounce Metal Castings
11. B88-2020 Standard Specification for Seamless Copper Water Tube
12. F439-2019 Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80
13. F441/F441M-2020 Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80

D. American Welding Society (AWS):
   1. B2.1/B2.1M-2014 Specification for Welding Procedure and Performance Qualification

E. Expansion Joint Manufacturer’s Association, Inc. (EJMA):
   1. Standards of the Expansion Joint Manufacturers Association, Tenth Edition

F. Manufacturers Standardization Society (MSS) of the Valve and Fitting Industry, Inc.:
   1. SP-67-2017 Butterfly Valves
   2. SP-70-2011 Gray Iron Gate Valves, Flanged and Threaded Ends
   3. SP-71-2018 Gray Iron Swing Check Valves, Flanged and Threaded Ends
   4. SP-80-2019 Bronze Gate, Globe, Angle, and Check Valves
   5. SP-85-2011 Gray Iron Globe and Angle Valves, Flanged and Threaded Ends
   6. SP-110-2010 Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends
   7. SP-125-2018 Gray Iron and Ductile Iron In-line, Spring-Loaded, Center-Guided Check Valves

G. National Fire Protection Association (NFPA):
   1. 70-2023 National Electrical Code (NEC)

H. Tubular Exchanger Manufacturers Association (TEMA):
   1. TEMA Standards-2007 9th Edition

1.4 SUBMITTALS

A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 23 21 13, HYDRONIC PIPING", with applicable paragraph identification.

C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.

1. Pipe and equipment supports.
    a. Submit calculations for variable spring and constant support hangers.
2. Pipe and tubing, with specification, class or type, and schedule.
3. Pipe fittings, including miscellaneous adapters and special fittings.
4. Flanges, gaskets and bolting.
5. Couplings and fittings.
6. Valves of all types.
7. Strainers.
8. Flexible connectors for water service.
9. Pipe alignment guides.
10. Expansion joints.
11. Expansion compensators.
12. All specified hydronic system components.
13. Water flow measuring devices.
14. Gauges.
15. Thermometers and test wells.
16. Electric heat tracing systems.
17. Seismic bracing details for piping.

D. Manufacturer's certified data report, Form No. U-1, for ASME pressure vessels:

1. Heat exchangers (Water to Water).
2. Air separators.

3. Expansion tanks.
4. Buffer tanks.

E. Submit the welder’s qualifications in the form of a current (less than 1-year old) and formal certificate.

F. Coordination Drawings: Refer to paragraph, SUBMITTALS of Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

G. As-Built Piping Diagrams: Provide drawings as follows for chilled water, condenser water, heating hot water, hydronic water, and other piping systems and equipment.
1. One complete set of reproducible drawings.
2. One complete set of drawings in electronic AutoCAD and pdf format.

H. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replacement parts, and troubleshooting guide:
1. Include complete list indicating all components of the systems.
2. Include complete diagrams of the internal wiring for each item of equipment.
3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

I. Completed System Readiness Checklist provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

J. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

1.5 QUALITY ASSURANCE

A. Section 23 05 11, COMMON WORK RESULTS FOR HVAC, which includes welding qualifications.

B. Submit prior to welding of steel piping a certificate of Welder’s certification. The certificate shall be current and not more than one-year old.

C. All couplings, fittings, valves, and specialties shall be the products of a single manufacturer.

D. All castings used for coupling housings, fittings, valve bodies, etc., shall be date stamped for quality assurance and traceability.

1.6 AS-BUILT DOCUMENTATION

A. Comply with requirements of Section 23 05 11, COMMON WORK RESULTS FOR HVAC, paragraph AS-BUILT DOCUMENTATION.

PART 2 PRODUCTS

2.1 PIPE AND EQUIPMENT SUPPORTS, PIPE SLEEVES, AND WALL AND CEILING PLATES

A. Provide in accordance with Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

2.2 PIPE AND TUBING

A. Hydronic Water Piping:
   1. Steel: ASTM A53/A53M Grade B, seamless or ERW, Schedule 40.
   2. Copper: ASTM B88, Type L, hard drawn.

B. Extension of Domestic Water Make-up Piping: ASTM B88, Type L, hard drawn copper tubing.

C. Condensate Drain Piping
   1. From air handling units, condensing units, and CRAC units:
      a. Copper water tube, ASTM B88, Type M.
   2. From fan coil, VRF indoor units, or other terminal units:
      a. Copper water tube, ASTM B88, Type M for runouts and Type L for mains.

D. Pipe supports, including insulation shields, for above ground piping: Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

2.3 FITTINGS FOR STEEL PIPE

A. 50 mm (2 inches) and Smaller: Screwed, welded, or grooved joints.
   1. Butt welding: ASME B16.9 with same wall thickness as connecting piping.
   2. Forged steel, socket welding or threaded: ASME B16.11.
   3. Screwed: 150-pound malleable iron, ASME B16.3. 125-pound cast iron, ASME B16.4, may be used in lieu of malleable iron. Bushing reduction of a single pipe size, or use of close nipples, is prohibited.

4. Mechanical Grooved Couplings: Installation ready without field disassembly. Shall consist of two ductile iron (ASTM A536, Grade 65-45-12) or malleable iron (ASTM A47, Grade 32510) housing segments. Gasket shall be pressure responsive elastomeric type (ASTM D2000). Bolts shall be zinc-electroplated steel track head type. Shall be for use on pipe and fittings grooved to the Manufacturer’s Specifications. Couplings and fittings to be of the same manufacturer.
5. Unions: ASME B16.39.
6. Water hose connection adapter: Brass, pipe thread to 19 mm (3/4 inch) garden hose thread, with hose cap nut.

B. 63 mm (2-1/2 inches) and Larger: Welded, flanged, or grooved joints.
1. Butt welding fittings: ASME B16.9 with same wall thickness as connecting piping. Elbows shall be long radius type, unless otherwise noted.
2. Welding flanges and bolting: ASME B16.5:
   a. Water service: Weld neck or slip-on, plain face, with 3.2 mm (1/8 inch) thick full-face neoprene gasket suitable for 104 degrees C (220 degrees F).
      1) Contractor's option: Convoluted, cold formed 150-pound steel flanges, with Teflon gaskets, may be used for water service.
   b. Flange bolting (systems other than heating hot water): Carbon steel machine bolts or studs and nuts, ASTM A307, Grade B.
   c. Flange bolting (heating hot water systems): Carbon steel machine bolts or studs and nuts, ASTM A193.
3. Mechanical Grooved Couplings: Installation ready without field disassembly. Shall consist of two ductile iron (ASTM A536, Grade 65-45-12) or malleable iron (ASTM A47, Grade 32510) housing segments. Gasket shall be pressure responsive elastomeric type (ASTM D2000). Bolts shall be zinc-electroplated steel track head type. Shall be for use on pipe and fittings grooved to the Manufacturer’s Specifications. Couplings and fittings to be of the same manufacturer.

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C. Welded Branch and Tap Connections: Forged steel weldolets, or branchlets and threadolets shall be used for branch connections up to 1 pipe size smaller than the main. Forged steel half-couplings, ASME B16.11 shall be used for drain, vent and gauge connections.

2.4 FITTINGS FOR COPPER TUBING

A. Joints:

1. Solder Joints: Joints shall be made up in accordance with recommended practices of the materials applied. Apply 95/5 tin and antimony on all copper piping.
2. Mechanically formed tee connection in water and drain piping: Form mechanically extracted collars in a continuous operation by drilling pilot hole and drawing out tube surface to form collar, having a height of not less than three times the thickness of tube wall. Adjustable collaring device shall ensure proper tolerance and complete uniformity of the joint. Notch and dimple joining branch tube in a single process to provide free flow where the branch tube penetrates the fitting.
3. Rolled/grooved fittings:
   a. Couplings: 200 PSI minimum joint working pressure, cast ductile iron housing conforming to ASTM A536. Gaskets for heating water or chilled water service, elastomer in accordance with ASTM D2000. Gaskets for heating water or chilled water service shall be elastomer per ASTM D2000. All grooved couplings shall be designed with angle bolt pads to provide rigid joint.
4. Flanges: 200 PSI minimum joint working pressure, cast ductile iron housing, suitable for bolting to ANSI Class-125 cast iron and 150 steel flanged components. Gasket material similar to coupling gasket material.
5. Press Fit Joints: Conforming to the material and sizing requirements of ASME B16.18 or ASME B16.22. O-ring for copper press fittings shall be EPDM.

B. Bronze Flanges and Flanged Fittings: ASME B16.24.

C. Fittings: ASME B16.18 cast copper or ASME B16.22 solder wrought copper.

2.5 FITTINGS FOR PLASTIC PIPING

A. Schedule 40, socket type for solvent welding.

B. Schedule 40 PVC drain piping: Drainage pattern.

2.6 DIELECTRIC FITTINGS

A. Provide where copper tubing and ferrous metal pipe are joined.

B. 50 mm (2 inches) and Smaller: Threaded dielectric union, ASME B16.39.

C. 65 mm (2-1/2 inches) and Larger: Flange union with dielectric gasket and bolt sleeves, ASME B16.42. Dielectric gasket material shall be compatible with hydronic medium.

D. Temperature Rating, 99 degrees C (210 degrees F).

E. Contractor’s option: On pipe sizes 50 mm (2 inch) and smaller, screwed end brass ball valves or dielectric nipples may be used in lieu of dielectric unions.

2.7 SCREWED JOINTS

A. Pipe Thread: ASME B1.20.1.

B. Lubricant or Sealant: Oil and graphite or other compound approved for the intended service.

2.8 VALVES

A. Asbestos packing is not acceptable.

B. All valves of the same type shall be products of a single manufacturer.

C. Provide chain operators for valves 150 mm (6 inches) and larger when the centerline is located 2.4 m (8 feet) or more above the floor or operating platform.

D. Shut-Off Valves:

1. Ball Valves (Pipe sizes 50 mm (2 inch) and smaller): MSS SP-110, screwed or solder connections, brass or bronze body with chrome-plated ball with full port and Teflon seat at 2758 kPa (400 psig) working pressure rating. Provide stem extension to allow operation without interfering with pipe insulation.

2. Butterfly Valves (Pipe Sizes 63 mm (2-1/2 inch) and larger): Provide stem extension to allow 50 mm (2 inches) of pipe insulation without interfering with valve operation. MSS SP-67, flange lug type rated 1200 kPa (175 psig) working pressure at 93 degrees C (200 degrees F). Valves shall be ANSI Leakage Class VI and rated for bubble tight shut-off to full valve pressure rating. Valve shall be rated for dead end service and bi-directional flow capability to full rated pressure. Butterfly valves are prohibited for direct buried pipe applications.
   a. Body: Cast iron, ASTM A126, Class B. Malleable iron, ASTM A47/A47M electro-plated, or ductile iron, ASTM A536, Grade 65-45-12 electro-plated.
   b. Trim: Bronze, aluminum bronze, or 300 series stainless steel disc, bronze bearings, 316 stainless steel shaft and manufacturer's recommended resilient seat. Resilient seat shall be field replaceable, and fully line the body to completely isolate the body from the product. A phosphate coated steel shaft or stem is acceptable, if the stem is completely isolated from the product.
3. Field Interchangeable Actuators: Valves for balancing service shall have adjustable memory stop to limit open position.
   a. Valves 152 mm (6 inches) and smaller: Lever actuator with minimum of seven locking positions, except where chain wheel is required.
   b. Valves 203 mm (8 inches) and larger: Enclosed worm gear with handwheel, and where required, chain-wheel operator.

E. Check Valves:
1. Non-Slam or Silent Check Valve: Spring loaded double disc swing check or internally guided flat disc lift type check for bubble tight shut-off. Provide where check valves are shown in chilled water and hot water piping. Check valves incorporating a balancing feature may be used.
   a. Body: MSS SP-125 cast iron, ASTM A126, Class B, or steel, ASTM A216/A216M, Class WCB, or ductile iron, ASTM 536, flanged or wafer type.

b. Seat, disc and spring: 18-8 stainless steel, or bronze, ASTM B62. Seats may be elastomer material.

F. Water Flow Balancing Valves: For flow regulation and shut-off. Valves shall be sized to provide the needed pressure drop in the middle of their throttling range.

1. Globe style valve.
2. A dual-purpose flow balancing valve and adjustable flow meter, with bronze or cast-iron body, calibrated position pointer, valved pressure taps or quick disconnects with integral check valves and preformed polyurethane insulating enclosure.
3. 1/2" through 2"
   a. The balancing valves shall be wye-pattern globe style design and all metal parts of nonferrous, pressure die cast, nonporous Ametal or bronze. Each valve shall provide four (4) functions: (1) Precision flow measurement, (2) Precision flow balancing, (3) Shut-off feature, eliminating the need of an additional isolation valve.
   b. These valves shall have eight (8), twelve (12) or sixteen (16) 360° adjustment turns of the handwheel for precise setting with hidden memory feature to program the valve with precision tamper-proof balancing setting. Handwheel shall have digital readout. The handwheel can be installed in any position without affecting performance.
   c. Valve shall be rated for 300 psi/2065 kPa, wye-pattern, globe type with soldered or threaded ends, non-ferrous Ametal® brass copper alloy body, EPDM o-ring seals. 4-turn digital readout handwheel for balancing, hidden memory feature with locking tamper-proof setting, and connections for portable differential meter.
   d. Union Port Fitting: Threaded end terminal hook-up with manual air-vent port. Forged brass union with EPDM O-ring.
   e. Test Ports: Self-sealing with EPDM seals.
   f. Valves shall be Victaulic/Tour and Andersson STAD or STAS series, Armstrong CBV series, or approved equal.
4. 2-1/2" through 12"

a. The balancing valves shall be wye-pattern globe style design with ductile iron body all other wetted parts of nonferrous, pressure die cast Ametal, bronze, or stainless steel. Each valve shall provide three (3) functions: (1) Precision flow measurement, (2) Precision flow balancing, (3) Shut-off feature, eliminating the need of an additional isolation valve.
b. These valves shall have eight (8), twelve (12) or sixteen (16) 360° adjustment turns of the handwheel for precise setting with hidden memory feature to program the valve with precision tamper-proof balancing setting. Handwheel shall have digital readout. The handwheel can be installed in any position without affecting performance.
c. Valve shall be rated for 300 psi/2065 kPa, wye-pattern, globe type with flanged or grooved ends, ASTM A536 ductile iron body, all other metal parts of Ametal® brass copper alloy, EPDM O-ring seals. 8, 12, 16, 20 or 22 turn digital readout handwheel for balancing, hidden memory feature with locking tamper-proof setting, and connections for portable differential meter.
d. Union Port Fitting: Threaded end terminal hook-up with manual air-vent port. Forged brass union with EPDM O-ring.
e. Test Ports: Self-sealing with EPDM seals.
f. Valves shall be Victaulic/Tour and Andersson STAF or STAG series, Armstrong CBV series, or approved equal.

5. Provide a readout kit including flow meter, readout probes, hoses, flow charts or calculator, and carrying case.

2.9 HYDRONIC SYSTEM COMPONENTS

A. Automatic Air Vent Valves: Cast iron or semi-steel body, 1034 kPa (150 psig) working pressure, stainless steel float, valve, valve seat and mechanism, minimum 13 mm (1/2 inch) water connection and 6 mm (1/4 inch) air outlet. Air outlet shall be piped to the nearest floor drain.

2.10 GAUGES, PRESSURE AND COMPOUND

A. ASME B40.100, Accuracy Grade 1A, (pressure, vacuum, or compound for air, oil or water), initial mid-scale accuracy 1 percent of scale (Qualify grade), metal or phenolic case, 114 mm (4-1/2 inches) in diameter, 6 mm (1/4 inch) NPT bottom connection, white dial with black graduations and pointer, clear glass or acrylic plastic window, glycerin filled as manufactured by TIF or approved equal.
   1. Guages shall be suitable for board or panel mounting.
   2. Provide red "set hand" to indicate normal working pressure.

B. Provide brass lever handle union cock. Provide brass/bronze pressure snubber for gauges in water service.

C. Range of Gauges: Provide range equal to at least 130 percent of normal operating range.

2.11 PRESSURE/TEMPERATURE TEST PROVISIONS

A. Pete's Plug: 6 mm (1/4 inch) MPT by 75 mm (3 inches) long, brass body and cap, with retained safety cap, Nordel self-closing valve cores, permanently installed in piping where shown, or in lieu of pressure gauge test connections shown in the contract documents.

B. Provide one each of the following test items to the COR:
   1. 6 mm (1/4 inch) FPT by 3.2 mm (1/8 inch) diameter stainless steel pressure gauge adapter probe for extra-long test plug.
   2. 89 mm (3-1/2 inch) diameter, one percent accuracy, compound gauge, 101 kPa (30 inches Hg) to 690 kPa (100 psig) range.
   3. 0 to 104 degrees C (32 to 220 degrees F) pocket thermometer 1/2 degree accuracy, 25 mm (1 inch) dial, 127 mm (5 inch) long stainless-steel stem, plastic case.

2.12 THERMOMETERS

A. 5” bimetal thermometer with stainless steel case and adjustable angle connection. Wika T1.52 or approved equal.

B. Case: Chrome plated brass or aluminum with enamel finish.

C. Scale: Not less than 225 mm (9 inches), range as described below, two-degree graduations.

D. Separable Socket (Well): Brass, extension neck type to clear pipe insulation.

E. Scale ranges:
   1. Chilled Water and Glycol-Water: 0 to 38 degrees C (32 to 100 degrees F).
   2. Hot Water and Glycol-Water: 38 to 93 degrees C (100 to 200 degrees F).

2.13 FIRESTOPPING MATERIAL

A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

PART 3 EXECUTION

3.1 GENERAL

A. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no additional cost or time to the Government.
B. The contract documents show the general arrangement of pipe and equipment but do not show all required fittings and offsets that may be necessary to connect pipes to equipment, fan-coils, coils, radiators, etc., and to coordinate with other trades. Provide all necessary fittings, offsets and pipe runs based on field measurements and at no additional cost or time to the Government. Coordinate with other trades for space available and relative location of HVAC equipment and accessories to be connected on ceiling grid. Pipe location in the contract documents shall be altered by contractor where necessary to avoid interferences and clearance difficulties.
C. Store materials to avoid excessive exposure to weather or foreign materials. Keep inside of piping relatively clean during installation and protect open ends when work is not in progress.
D. Support piping securely. Refer to PART 3, Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

E. Install piping generally parallel to walls and column center lines, unless shown otherwise in the contract documents. Space piping, including insulation, to provide 25 mm (1 inch) minimum clearance between adjacent piping or other surface. Unless shown otherwise, slope drain piping down in the direction of flow not less than 25 mm (1 inch) in 12 m (40 feet). Provide eccentric reducers to keep bottom of sloped piping flat.

F. Locate and orient valves to permit proper operation and access for maintenance of packing, seat and disc. Generally, locate valve stems in overhead piping in horizontal position. Provide a union adjacent to one end of all threaded end valves. Control valves usually require reducers to connect to pipe sizes shown in the contract documents. Install butterfly valves with the valve open as recommended by the manufacturer to prevent binding of the disc in the seat.

G. Offset equipment connections to allow valving off for maintenance and repair with minimal removal of piping. Provide flexibility in equipment connections and branch line take-offs with 3-elbow swing joints where noted in the contract documents.

H. Tee water piping runouts or branches into the side of mains or other branches. Avoid bull-head tees, which are two return lines entering opposite ends of a tee and exiting out the common side.

I. Provide manual or automatic air vent at all piping system high points and drain valves at all low points. Install piping to floor drains from all automatic air vents.

J. Connect piping to equipment as shown in the contract documents. Install components furnished by others such as:
   1. Water treatment pot feeders and condenser water treatment systems.
   2. Flow elements (orifice unions), control valve bodies, flow switches, pressure taps with valve, and wells for sensors.

K. Thermometer Wells: In pipes 65 mm (2-1/2 inches) and smaller increase the pipe size to provide free area equal to the upstream pipe area.

L. Firestopping: Fill openings around uninsulated piping penetrating floors or fire walls, with firestop material. For firestopping insulated piping refer to Section 23 07 11, HVAC AND BOILER PLANT INSULATION.

M. Where copper piping is connected to steel piping, provide dielectric connections.

3.2 PIPE JOINTS

A. Welded: Beveling, spacing and other details shall conform to ASME B31.9 and AWS B2.1/B2.1M. Refer to welder's qualification requirements in Section 23 05 11, COMMON WORK RESULTS FOR HVAC, paragraph QUALITY ASSURANCE.

B. Screwed: Threads shall conform to ASME B1.20.1; joint compound shall be applied to male threads only and joints made up so no more than three threads show. Coat exposed threads on steel pipe with joint compound, or red lead paint for corrosion protection.

C. 125 Pound Cast Iron Flange (Plain Face): Mating flange shall have raised face, if any, removed to avoid overstressing the cast iron flange.

D. Grooved:

1. Install in accordance with manufacturer's recommendation including field grooving and gasket lubrication.
2. Provide on-site installer training required by grooved fitting manufacturer.
3. Use roll grooves, except when pipe wall thickness does not permit. When galvanized pipe is field grooved, paint worked area with zinc chromated aluminum paint to repair galvanizing.
4. Manufacturer's representative shall submit a written report to the COR noting work progress, areas and items reviewed, and an evaluation of the installation. The contractor shall pay all costs for the manufacturer's review & report. The contractor shall remove & replace any work deemed improper or defective by the manufacturer's representative or by the COR.

3.3 SEISMIC BRACING FOR ABOVEGROUND PIPING

A. Provide in accordance with Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

3.4 LEAK TESTING ABOVEGROUND PIPING

A. Inspect all joints and connections for leaks and workmanship and make corrections as necessary, to the satisfaction of the COR. Tests shall be either of those below, or a combination, as approved by the COR.

B. An operating test at design pressure, and for hot systems, design maximum temperature.

C. A hydrostatic test at 1.5 times design pressure. For water systems, the design maximum pressure would usually be the static head, or expansion tank maximum pressure, plus pump head. Factory tested equipment (convertors, exchangers, coils, etc.) need not be field tested. Isolate equipment where necessary to avoid excessive pressure on mechanical seals and safety devices.

3.5 FLUSHING AND CLEANING PIPING SYSTEMS

A. Water Piping: Clean systems as recommended by the suppliers of chemicals specified in Section 23 25 00, HVAC WATER TREATMENT.

B. Initial Flushing: Remove loose dirt, mill scale, metal chips, weld beads, rust, and like deleterious substances without damage to any system component. Provide temporary piping or hose to bypass coils, control valves, exchangers and other factory cleaned equipment unless acceptable means of protection are provided and subsequent inspection of hide-out areas takes place. Isolate or protect clean system components, including pumps and pressure vessels, and remove any component which may be damaged. Open all valves, drains, vents and strainers at all system levels. Remove plugs, caps, spool pieces, and components to facilitate early debris discharge from system. Sectionalize system to obtain debris carrying velocity of 1.8 m/s (5.9 f/s), if possible. Connect dead-end supply and return headers as necessary. Flush bottoms of risers. Install temporary strainers where necessary to protect down-stream equipment. Supply and remove flushing water and drainage by various type hose, temporary and permanent piping and Contractor's booster pumps. Flush until clean as approved by the COR.

C. Cleaning: Using products supplied in Section 23 25 00, HVAC WATER TREATMENT, circulate systems at normal temperature to remove adherent organic soil, hydrocarbons, flux, pipe mill varnish, pipe joint compounds, iron oxide, and like deleterious substances not removed by flushing, without chemical or mechanical damage to any system component. Removal of tightly adherent mill scale is not required. Keep isolated equipment which is "clean" and where dead-end debris accumulation cannot occur. Sectionalize system if possible, to circulate at velocities not less than 1.8 m/s (5.9 f/s). Circulate each section for not less than 4 hours. Blow-down all strainers, or remove and clean as frequently as necessary. Drain and prepare for final flushing.

D. Final Flushing: Return systems to conditions required by initial flushing after all cleaning solution has been displaced by clean make-up. Flush all dead ends and isolated clean equipment. Gently operate all valves to dislodge any debris in valve body by throttling velocity. Flush for not less than one hour.

3.6 WATER TREATMENT

A. Install water treatment equipment and provide water treatment system piping.

B. Close and fill system as soon as possible after final flushing to minimize corrosion.

C. Charge systems with chemicals specified in Section 23 25 00, HVAC WATER TREATMENT.

D. Utilize this activity, by arrangement with the COR, for instructing VA operating personnel.

3.7 STARTUP AND TESTING

A. Perform tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.

B. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.

C. The CxA will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with COR and CxA. Provide a minimum notice of 10 working days prior to startup and testing.
D. Adjust red set hand on pressure gauges to normal working pressure.

3.8 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
B. Components provided under this section of the specification will be tested as part of a larger system.

3.9 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer’s technical representative for 4 hours to instruct each VA personnel responsible in operation and maintenance of the system.
B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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SECTION 23 22 13
STEAM AND CONDENSATE HEATING PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Steam, condensate, and vent piping inside buildings.

B. Outside steam distribution piping is covered in specification Section 33 63 00, STEAM ENERGY DISTRIBUTION.

1.2 RELATED WORK

A. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Section 07 84 00, JOINT FIRESTOPPING.

C. Section 07 84 13, PENETRATION FIRESTOPPING.

D. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

E. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

F. Section 23 07 11, HVAC AND BOILER PLANT INSULATION.

G. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

H. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

I. Section 23 25 00, HVAC WATER TREATMENT.

1.3 QUALITY ASSURANCE

A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC, which includes welding qualifications.

B. The products and execution of work specified in this section shall conform to the referenced codes and standards as required by the specifications. Local codes and amendments shall be enforced, along with requirements of local utility companies. The most stringent requirements of these specifications, local codes, or utility company requirements shall always apply. Any conflicts shall be brought to the attention of the COR.

C. Welding Qualifications: Before any welding is performed, contractor shall submit a certificate certifying that welders comply with the following requirements:

D. Qualify welding processes and operators for piping according to ASME BPVC Section IX, AWS Z49.1 and AWS B2.1/B2.1M.

E. Comply with provisions in ASM B31.1 and ASME B31.9.

F. Certify that each welder and welding operator has passed AWS qualification tests for welding processes involved and that certification is current and recent. Submit documentation to the COR.

G. All welds shall be stamped according to the provisions of the American Welding Society.

H. ASME Compliance: Comply with ASM B31.1 and ASME B31.9 for materials, products, and installation. Safety valves and pressure vessels shall bear appropriate ASME labels.

1.4 SUBMITTALS

A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.

B. Manufacturer's Literature and Data:

1. Pipe and equipment supports.
    a. Submit calculations for variable spring and constant support hangers.
2. Pipe and tubing, with specification, class or type, and schedule.
3. Pipe fittings, including miscellaneous adapters and special fittings.
4. Flanges, gaskets and bolting.

C. Manufacturer's certified data report, Form No. U-1, for ASME pressure vessels:

1. Heat Exchangers (Steam-to-Hot Water).
2. Flash tanks.

D. Coordination Drawings: Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC paragraph SUBMITTALS.

E. Record Documents: Provide drawing as follows for steam and steam condensate piping and other central plant equipment.

1.5 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Where conflicts occur these specifications and the VHA standards shall govern.

B. American Society of Mechanical Engineers (ASME):

1. B1.20.1-2013 Pipe Threads, General Purpose (Inch)

2. B16.5-2020 Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard
3. B16.9-2018 Factory Made Wrought Buttwelding Fittings
4. B16.11-2016 Forged Fittings, Socket-Welding and Threaded
5. B16.42-2016 Ductile Iron Pipe Flanges and Flanged Fittings: Classes 150 and 300
6. B31.1-2020 Power Piping
7. B31.9-2020 Building Services Piping
8. B40.100-2013 Pressure Gauges and Gauge Attachments
9. ASME Boiler and Pressure Vessel Code (BPVC)
   a. BPVC Section II-2021 Materials
   b. BPVC Section VIII 2021 Rules for Construction of Pressure Vessels, Division 1
   c. BPVC Section IX-2021 Welding, Brazing, and Fusing Qualifications

C. American Society for Testing and Materials (ASTM):
1. A53/A53M-2020 Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
2. A106/A106M-2019a Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
3. A216/A216M-2018 Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service
4. A285/A285M-2017 Standard Specification for Pressure Vessel Plates, Carbon Steel, Low-and Intermediate-Tensile Strength
5. A307-2014e1 Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 PSI Tensile Strength
6. A516/A516M-2017 Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service
7. A536-1984(2019)e1 Standard Specification for Ductile Iron Castings
8. B62-2017 Standard Specification for Composition Bronze or Ounce Metal Castings

D. American Welding Society (AWS):
1. B2.1/B2.1M-2014 Specification for Welding Procedure and Performance Qualifications
2. Z49.1-2012 Safety in Welding and Cutting and Allied Processes

E. Manufacturers Standardization Society (MSS) of the Valve and Fitting Industry, Inc.:
   1. SP-80-2019 Bronze Gate, Globe, Angle, and Check Valves
F. Military Specifications (Mil. Spec.):
   1. MIL-DTL-901E-2017 Shock Tests, H.I. (High Impact) Shipboard Machinery, Equipment, and Systems
G. National Board of Boiler and Pressure Vessel Inspectors (NB):
   1. Relieving Capacities of Safety Valves and Relief Valves
H. Tubular Exchanger Manufacturers Association (TEMA):
   1. TEMA Standards-2019 10th Edition

1.6 AS-BUILT DOCUMENTATION

A. Comply with requirements of Section 23 05 11, COMMON WORK RESULTS FOR HVAC paragraph AS-BUILT DOCUMENTATION.

PART 2 - PRODUCTS

2.1 PIPE AND EQUIPMENT SUPPORTS, PIPE SLEEVES, AND WALL AND CEILING PLATES

A. Provide in accordance with Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

2.2 PIPE AND TUBING

A. Steam Piping: Steel, ASTM A53/A53M, Grade B, schedule 80, seamless or ERW; or A106/A106M Grade B, seamless, schedule 80.
B. Steam Condensate and Pumped Condensate Piping:
   1. Concealed above ceiling, in wall or chase: Copper water tube ASTM B88, Type K, hard drawn.
   2. All other locations: Copper water tube ASTM B88, Type K, hard drawn; or steel, ASTM A53/A53M, Grade B, seamless or ERW, schedule 80, or A106/A106M Grade B seamless, schedule 80.
C. Vent Piping: Steel, ASTM A53/A53M, Grade B, seamless or ERW, schedule 40, galvanized; or A106/A106M Grade B, seamless, Schedule 40, galvanized.

2.3 FITTINGS FOR STEEL PIPE

A. 50 mm (2 inches) and Smaller: Screwed or welded.

1. Cast iron fittings or piping is prohibited for steam and steam condensate piping. Bushing reduction or use of close nipples is prohibited.
2. Butt welding fittings: ASME B16.9 with same wall thickness as connecting piping. Elbows shall be long radius type, unless otherwise noted.
3. Forged steel, socket welding or threaded: ASME B16.11, 13,790 kPa (2000 psig) class with ASME B1.20.1 threads. Use Schedule 80 pipe and fittings for threaded joints. Lubricant or sealant shall be oil and graphite, or other compound approved for the intended service.
4. Unions: Forged steel, 13,790 kPa (2000 psig) class or 20,685 kPa (3000 psig) class on piping 50 mm (2 inches) and less.
5. Steam line drip station and strainer quick-couple blowdown hose connection: Straight through, plug and socket, screw or cam locking type for 15 mm (1/2 inch) ID hose. No integral shut-off is required.
6. Flange bolting: Carbon steel machine bolts or studs and nuts, ASTM A193.
7. Pipe Thread: ANSI B1.20.
8. Lubricant or Sealant: Oil and graphite or other compound approved for the intended service.

B. 65 mm (2-1/2 inches) and Larger: Welded or flanged joints.
1. Cast iron fittings or piping is prohibited for steam and steam condensate piping.
2. Butt welding fittings: ASME B16.9 with same wall thickness as connecting piping. Elbows shall be long radius type, unless otherwise noted.
3. Welding flanges and bolting: ASME B16.5:
   a. Steam service: Weld neck or slip-on, raised face, with non-asbestos gasket. Non-asbestos gasket shall either be stainless steel spiral wound strip with flexible graphite filler or compressed inorganic fiber with nitrile binder rated for saturated and superheated steam service 400 degrees C (750 degrees F) and 10,342 kPa (1500 psig).

b. Flange bolting: Carbon steel machine bolts or studs and nuts, ASTM A193.

C. Welded Branch and Tap Connections: Forged steel weldolets, or branchlets and threadolets may be used for branch connections up to one pipe size smaller than the main. Forged steel half-couplings, ASME B16.11 may be used for drain, vent and gage connections.

2.4 FITTINGS FOR COPPER TUBING

A. Solder Joint:
1. Joints shall be made up in accordance with recommended practices of the materials applied. Apply 95/5 tin and antimony on all copper piping.

B. Bronze Flanges and Flanged Fittings: ASME B16.24.

C. Fittings: ANSI/ASME B16.18 cast copper or ANSI/ASME B16.22 solder wrought copper.

D. Flange bolting: Carbon steel machine bolts or studs and nuts, ASTM A193.

2.5 DIELECTRIC FITTINGS

A. Provide where copper tubing and ferrous metal pipe are joined.

B. 50 mm (2 inches) and Smaller: Threaded dielectric union, ASME B16.39.

C. 65 mm (2 1/2 inches) and Larger: Flange union with dielectric gasket and bolt sleeves, ASME B16.42.

D. Temperature Rating, 121 degrees C (250 degrees F) for steam condensate and as required for steam service.

E. Contractor’s option: On pipe sizes 2” and smaller, screwed end brass gate valves or dielectric nipples may be used in lieu of dielectric unions.

2.6 FIRESTOPPING MATERIAL

A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

PART 3 - EXECUTION

3.1 GENERAL

A. If in the substantiated evaluation of the COR, the installation fails to meet the requirements of the construction documents with respect to function and maintainability, an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no additional cost or time to the Government.

B. The contract documents show the general arrangement of pipe and equipment but do not show all required fittings and offsets that may be necessary to connect pipes to equipment, fan-coils, coils, radiators, etc., and to coordinate with other trades. Provide all necessary fittings, offsets and pipe runs based on field measurements and at no additional cost or time to the Government. Coordinate with other trades for space available and relative location of HVAC equipment and accessories to be connected on ceiling grid. Pipe location in the contract documents shall be altered by contractor where necessary to avoid interferences and clearance difficulties.

C. Store materials to avoid excessive exposure to weather or foreign materials. Keep inside of piping relatively clean during installation and protect open ends when work is not in progress.

D. Support piping securely. Refer to PART 3, Section 23 05 11, COMMON WORK RESULTS FOR HVAC. Install convertors and other heat exchangers at height sufficient to provide gravity flow of condensate to the flash tank and condensate pump.

E. Install piping generally parallel to walls and column center lines, unless shown otherwise in the contract documents. Space piping, including insulation, to provide 25 mm (1 inch) minimum clearance between adjacent piping and another surface. Unless shown otherwise, slope steam, condensate and drain piping down in the direction of flow not less than 25 mm (1 inch) in 12 m (40 feet). Provide eccentric reducers to keep bottom of sloped piping flat.

F. Offset equipment connections to allow valving off for maintenance and repair with minimal removal of piping. Provide flexibility in equipment connections and branch line take-offs with 3-elbow swing joints where noted in the contract documents.

G. Tee water piping runouts or branches into the side of mains or other branches. Avoid bull-head tees, which are two return lines entering opposite ends of a tee and exiting out the common side.

H. Connect piping to equipment as shown in the contract documents. Install components furnished by others such as flow elements (orifice unions), control valve bodies, flow switches, pressure taps with valve, and wells for sensors.

I. Firestopping: Fill openings around uninsulated piping penetrating floors or fire walls, with firestop material. For firestopping insulated piping refer to Section 23 07 11, HVAC AND BOILER PLANT INSULATION.

J. Contract documents do not identify all locations where steam trap sets are required. Contractor shall provide at no additional cost as many trap-sets as are necessary for the proper, reliable operation of the system. Provide trap-sets at all low points and at 61 meter (200 feet) intervals on all horizontal main lines.

3.2 WELDING

A. The contractor is entirely responsible for the quality of the welding and shall:

1. Conduct tests of the welding procedures used on the project, verify the suitability of the procedures used, verify that the welds made will meet the required tests, and also verify that the welding operators have the ability to make sound welds under standard conditions.
2. Perform all welding operations required for construction and installation of the piping systems.

B. Qualification of Welders: Rules of procedure for qualification of all welders and general requirements for fusion welding shall conform with the applicable portions of ASME B31.1, AWS B2.1/B2.1M, AWS Z49.1, and also as outlined below.

C. Examining Welder: Examine each welder at job site, in the presence of the COR, to determine the ability of the welder to meet the qualifications required. Test welders for piping for all positions, including welds with the axis horizontal (not rolled) and with the axis vertical. Each welder shall be allowed to weld only in the position in which he has qualified and shall be required to identify his welds with his specific code marking signifying his name and number assigned.

D. Examination Results: Provide the COR with a list of names and corresponding code markings. Retest welders who fail to meet the prescribed welding qualifications. Disqualify welders, who fail the second test, for work on the project.

E. Beveling: Field bevels and shop bevels shall be done by mechanical means or by flame cutting. Where beveling is done by flame cutting, surfaces shall be thoroughly cleaned of scale and oxidation just prior to welding. Conform to specified standards.

F. Alignment: Provide approved welding method for joints on all pipes greater than 50 mm (2 inches) to assure proper alignment, complete weld penetration, and prevention of weld spatter reaching the interior of the pipe.

G. Erection: Piping shall not be split, bent, flattened, or otherwise damaged before, during, or after installation. If the pipe temperature falls to 0 degrees C (32 degrees F) or lower, the pipe shall be heated to approximately 38 degrees C (100 degrees F) for a distance of 300 mm (1 foot) on each side of the weld before welding, and the weld shall be finished before the pipe cools to 0 degrees C (32 degrees F).

H. Non-Destructive Examination of Piping Welds:

1. Perform radiographic examination of 50 percent of the first 10 welds made and 10 percent of all additional welds made. The COR reserves the right to identify individual welds for which the radiographic examination shall be performed. All welds will be visually inspected by the COR. The VA reserves the right to require testing on additional welds up to 100 percent if greater than 25 percent of the examined welds fail the inspection.

2. An approved independent testing firm regularly engaged in radiographic testing shall perform the radiographic examination of pipe joint welds. All radiographs shall be reviewed and interpreted by an ASNT Certified Level III radiographer, employed by the testing firm, who shall sign the reading report.
3. Comply with ASME B31.1. Furnish a set of films showing each weld inspected, a reading report evaluating the quality of each weld, and a location plan showing the physical location where each weld is to be found in the completed project. The COR and the CxA will be given a copy of all reports to be maintained as part of the project records and shall review all inspection records.

I. Defective Welds: Replace and reinspect defective welds. Repairing defective welds by adding weld material over the defect or by peening are prohibited. Welders responsible for defective welds shall be requalified prior to resuming work on the project.

J. Electrodes: Electrodes shall be stored in a dry heated area, and be kept free of moisture and dampness during the fabrication operations. Discard electrodes that have lost part of their coating.

3.3 PIPE JOINTS

A. Welded: Beveling, spacing and other details shall conform to ASME B31.1 and AWS B2.1/B2.1M. See Welder’s qualification requirements under "Quality Assurance" in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

B. Screwed: Threads will conform to ASME B1.20.1; joint compound shall be applied to male threads only and joints made up so no more than three threads show. Coat exposed threads on steel pipe with joint compound, or red lead paint for corrosion protection.

C. 125 Pound Cast Steel Flange (Plain Face): Mating flange shall have raised face, if any, removed to avoid overstressing the cast steel flange.

3.4 STEAM TRAP PIPING

A. Install to permit gravity flow to the trap. Provide gravity flow (avoid lifting condensate) from the trap where modulating control valves are used. Support traps weighing over 11 kg (24 pounds) independently of connecting piping.
   1. On pipe size 1-1/2 inch and greater a raised face flange is required to allow for removal of the steam trap without disturbing surrounding piping.
   2. On pipe size less than 1-1/2 inch raised face flanges or unions may be used to allow for removal of the traps.

3.5 SEISMIC BRACING

A. Provide in accordance with Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

3.6 LEAK TESTING

A. Inspect all joints and connections for leaks and workmanship and make corrections as necessary, to the satisfaction of the COR in accordance with the specified requirements. Testing shall be performed in accordance with the specification requirements.
B. An operating test at design pressure, and for hot systems, design maximum temperature.
C. A hydrostatic test at 1.5 times design pressure. For water systems, the design maximum pressure would usually be the static head, or expansion tank maximum pressure, plus pump head. Factory tested equipment (convertors, exchangers, coils, etc.) need not be field tested. Avoid excessive pressure on mechanical seals and safety devices.
D. Prepare and submit test and inspection reports to the COR within 5 working days of test completion and prior to covering the pipe.
E. All tests shall be witnessed by the COR, their representative, or the CxA and be documented by each section tested, date tested, and list or personnel present.

3.7 FLUSHING AND CLEANING PIPING SYSTEMS

A. Steam, Condensate and Vent Piping: The piping system shall be flushed clean prior to equipment connection. Cleaning includes pulling all strainer screens and cleaning all scale/dirt legs during startup operation. Contractor shall be responsible for damage caused by inadequately cleaned/flushed systems.

3.8 STARTUP AND TESTING

A. Perform tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.

B. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.

C. The CxA will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with COR and Commissioning Agent. Provide a minimum notice of 10 working days prior to startup and testing.

D. Adjust red set hand on pressure gauges to normal working pressure.

3.9 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

B. Components provided under this section of the specification shall be tested as part of a larger system.

3.10 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer’s technical representative for 2 hours to instruct each VA personnel responsible in operation and maintenance of the system.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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SECTION 23 23 00
REFRIGERANT PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Field installed refrigerant piping for direct expansion HVAC systems, including required pipe insulation.

B. Refrigerant piping shall be sized, selected, and designed either by the equipment manufacturer or in strict accordance with the manufacturer's published instructions. The schematic piping diagram shall show all accessories such as, stop valves, level indicators, liquid receivers, oil separator, gauges, thermostatic expansion valves, solenoid valves, moisture separators and driers to make a complete installation.

1.2 DEFINITIONS:

A. Refrigerating system: Combination of interconnected refrigerant-containing parts constituting one closed refrigeration circuit in which a refrigerant is circulated for the purpose of extracting heat.

1. Low side means the parts of a refrigerating system subjected to evaporator pressure.
2. High side means the parts of a refrigerating system subjected to condenser pressure.

B. Brazed joint: A gas-tight joint obtained by the joining of metal parts with alloys which melt at temperatures higher than 449 degrees C (840 degrees F) but less than the melting temperatures of the joined parts.

1.3 RELATED WORK

A. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Section 07 84 00, JOINT FIRESTOPPING.

C. Section 07 84 13, PENETRATION FIRESTOPPING.

D. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

E. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

F. Section 23 07 11, HVAC AND BOILER PLANT INSULATION.

G. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

H. Section 23 81 00, DECENTRALIZED UNITARY HVAC EQUIPMENT.

I. Section 23 81 23, COMPUTER-ROOM AIR CONDITIONERS.

J. Section 23 81 45, VARIABLE REFRIGERANT FLOW SYSTEMS.

1.4 QUALITY ASSURANCE

A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

B. Comply with ASHRAE Standard 15, Safety Code for Mechanical Refrigeration. The application of this Code is intended to assure the safe design, construction, installation, operation, and inspection of every refrigerating system employing a fluid which normally is vaporized and liquefied in its refrigerating cycle.

C. Comply with ASME B31.5: Refrigerant Piping and Heat Transfer Components.

D. Products shall comply with UL 207 "Refrigerant-Containing Components and Accessories, "Nonelectrical"; or UL 429 "Electrical Operated Valves."

1.5 SUBMITTALS

A. Submit in accordance with specification Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.

B. Shop Drawings:

1. Complete information for components noted, including valves and refrigerant piping accessories, clearly presented, shall be included to determine compliance with drawings and specifications for components noted below:
   a. Tubing and fittings
   b. Valves
   c. Flexible metal hose
   d. Refrigerants and oil
   e. Oils
   f. Soldering and brazing materials
2. Layout of refrigerant piping and accessories, including flow capacities, valves locations, and oil traps slopes of horizontal runs, floor/wall penetrations, and equipment connection details.
3. Location of all access panels shall be indicated on shop drawings.

C. Certification: Copies of certificates for welding procedure, performance qualification record and list of welders' names and symbols.

1.6 APPLICABLE PUBLICATIONS

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

B. American Society of Heating Refrigerating and Air Conditioning Engineers (ASHRAE):
   1. 15-2019 Safety Standard for Refrigeration Systems (ANSI)

C. American National Standards Institute (ANSI):
   1. A13.1-2015 Scheme for Identification of Piping Systems
   2. Z535.1-2017 Safety Color Code

D. American Society of Mechanical Engineers (ASME):
   1. B16.22-2018 Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings (ANSI)
   2. B31.5-2013 Refrigeration Piping and Heat Transfer Components (ANSI)
   3. B40.100-2013 Pressure Gauges and Gauge Attachments

E. American Society for Testing and Materials (ASTM)
   1. B32-2008 Standard Specification for Solder Metal
   2. B88-2016 Standard Specification for Seamless Copper Water Tube
   3. B88M-2018 Standard Specification for Seamless Copper Water Tube (Metric)
   4. B280-2019 Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service

F. American Welding Society, Inc. (AWS):
   1. Brazing Handbook
   2. A5.8/A5.8M-2011 Standard Specification for Filler Metals for Brazing and Braze Welding

G. Underwriters Laboratories (U.L.):
   1. U.L.207-2018 Standard for Refrigerant-Containing Components and Accessories, Nonelectrical
   2. U.L.429-2013 Standard for Electrically Operated Valves

PART 2 - PRODUCTS

2.1 PIPING AND FITTINGS

A. Refrigerant Piping:

1. For piping up to 100 mm (4 inch) use copper refrigerant tube, ASTM B280, cleaned, dehydrated and sealed, marked ACR on hard temper straight lengths.

B. Refrigerant Piping Kits for Mini-Split Systems:

1. All refrigerant lines between outdoor and indoor units shall be of annealed, refrigeration grade copper tubing, ACR Type, meeting ASTM B280 or B1003 requirements, individually insulated in twin-tube, flexible, closed-cell, CFC-free (ozone depletion potential of zero), elastomeric material for the insulation of refrigerant pipes and tubes with thermal conductivity equal to or better than 0.27 BTU-inch/hour per Sq Ft / °F, a water vapor transmission equal to or better than 0.08 Perm-inch and superior fire ratings such that insulation will not contribute significantly to fire and up to 1” thick insulation shall have a Flame-Spread Index of 25 or less and a Smoke-development Index of 50 or less as tested by ASTM E 84 and CAN / ULC S-102.

C. Water and Drain Piping: Copper water tube, ASTM B88M, Type B or C (ASTM B88, Type L or M).

D. Fittings, Valves and Accessories:

1. Copper fittings: Wrought copper fittings, ASME B16.22.
   a. Brazed Joints, refrigerant tubing: Cadmium free, AWS A5.8/A5.8M, 45 percent silver brazing alloy, Class BAg-5.
      1) Brazing alloys shall have minimum brazing temperature of 1350°F.
   b. Solder Joints, water and drain: 95/5 tin-antimony, ASTM B32 (95TA).
2. Flanges and flanged fittings: ASME B16.24.
3. Refrigeration Valves:
   a. Stop Valves: Brass or bronze alloy, packless, or packed type with gas tight cap, frost proof, back seating.

4. Strainers: Designed to permit removing screen without removing strainer from piping system, and provided with screens 80 to 100 mesh in liquid lines DN 25 (NPS 1) and smaller, 60 mesh in liquid lines larger than DN 25 (NPS 1), and 40 mesh in suction lines. Provide strainers in liquid line serving each thermostatic expansion valve, and in suction line serving each refrigerant compressor not equipped with integral strainer.
5. Flexible Metal Hose: Seamless bronze corrugated hose, covered with bronze wire braid, with standard copper tube ends. Provide in suction and discharge piping of each compressor.

2.2 PIPE SUPPORTS

A. Refer to specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

2.3 REFRIGERANTS

A. Refer to Section 23 81 00, DECENTRALIZED UNITARY HVAC EQUIPMENT, Section 23 81 23, COMPUTER-ROOM AIR-CONDITIONERS, and Section 23 81 45, VARIABLE REFRIGERANT FLOW SYSTEMS.

2.4 OILS

A. Refer to Section 23 81 00, DECENTRALIZED UNITARY HVAC EQUIPMENT, Section 23 81 23, COMPUTER-ROOM AIR-CONDITIONERS, and Section 23 81 45, VARIABLE REFRIGERANT FLOW SYSTEMS.

2.5 PIPE/CONDUIT ROOF PENETRATION COVER

A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

2.6 PIPE INSULATION FOR DX HVAC SYSTEMS

A. Refer to specification Section 23 07 11, HVAC AND BOILER PLANT INSULATION.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install refrigerant piping and refrigerant containing parts in accordance with ASHRAE Standard 15 and ASME B31.5
   1. Install piping as short as possible, with a minimum number of joints, elbow and fittings.

2. Install piping with adequate clearance between pipe and adjacent walls and hangers to allow for service and inspection. Space piping, including insulation, to provide 25 mm (1 inch) minimum clearance between adjacent piping or other surface. Use pipe sleeves through walls, floors, and ceilings, sized to permit installation of pipes with full thickness insulation.
3. Locate and orient valves to permit proper operation and access for maintenance of packing, seat and disc. Generally locate valve stems in overhead piping in horizontal position. Provide a union adjacent to one end of all threaded end valves. Control valves usually require reducers to connect to pipe sizes shown on the drawing.
4. Use copper tubing in protective conduit when installed below ground.
5. Install hangers and supports per ASME B31.5 and the refrigerant piping manufacturer's recommendations.

B. Joint Construction:
1. Brazed Joints: Comply with AWS "Brazing Handbook" and with filler materials complying with AWS A5.8/A5.8M.
   a. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper tubing.
   b. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.
   c. Swab fittings and valves with manufacturer's recommended cleaning fluid to remove oil and other compounds prior to installation.
   d. Pass nitrogen gas through the pipe or tubing to prevent oxidation as each joint is brazed. Cap the system with a reusable plug after each brazing operation to retain the nitrogen and prevent entrance of air and moisture.

C. Protect refrigerant system during construction against entrance of foreign matter, dirt and moisture; have open ends of piping and connections to compressors, condensers, evaporators and other equipment tightly capped until assembly.

D. Pipe relief valve discharge to outdoors for systems containing more than 45 kg (100 lbs) of refrigerant.

E. Firestopping: Fill openings around uninsulated piping penetrating floors or fire walls, with firestop material. For firestopping insulated piping refer to Section 23 07 11, HVAC AND BOILER PLANT INSULATION.

F. Seismic Bracing: Refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS, for bracing of piping & equipment in seismic areas.

G. Provide access panels for all field-made refrigerant piping joints. Where possible, group multiple field-made joints in locations where a single access panel can be used for access.

3.2 PIPE AND TUBING INSULATION

A. Refer to Section 23 07 11, HVAC AND BOILER PLANT INSULATION.

3.3 SIGNS AND IDENTIFICATION

A. Each refrigerating system erected on the premises shall be provided with an easily legible permanent sign securely attached and easily accessible, indicating thereon the name and address of the installer, the kind and total number of pounds of refrigerant required in the system for normal operations, and the field test pressure applied.

3.4 FIELD QUALITY CONTROL

Prior to initial operation examine and inspect piping system for conformance to plans and specifications and ASME B31.5. Correct equipment, material, or work rejected because of defects or nonconformance with plans and specifications, and ANSI codes for pressure piping.

A. After completion of piping installation and prior to initial operation, conduct test on piping system according to ASME B31.5. Furnish materials and equipment required for tests. Perform tests in the presence of COR. If the test fails, correct defects and perform the test again until it is satisfactorily done and all joints are proved tight.

1. Every refrigerant-containing parts of the system that is erected on the premises, except compressors, condensers, evaporators, safety devices, pressure gages, control mechanisms and systems that are factory tested, shall be tested and proved tight after complete installation, and before operation.
2. The high and low side of each system shall be tested and proved tight at not less than the lower of the design pressure or the setting of the pressure-relief device protecting the high or low side of the system, respectively, except systems erected on the premises using non-toxic and non-flammable Group A1 refrigerants with copper tubing not exceeding DN 18 (NPS 5/8). This may be tested by means of the refrigerant charged into the system at the saturated vapor pressure of the refrigerant at 20 degrees C (68 degrees F) minimum.

B. Test Medium: A suitable dry gas such as nitrogen shall be used for pressure testing. The means used to build up test pressure shall have either a pressure-limiting device or pressure-reducing device with a pressure-relief device and a gage on the outlet side. The pressure relief device shall be set above the test pressure but low enough to prevent permanent deformation of the system components.

3.5 SYSTEM TEST AND CHARGING

A. System Test and Charging: As recommended by the equipment manufacturer or as follows:
1. Connect a drum of refrigerant to charging connection and introduce enough refrigerant into system to raise the pressure to 70 kPa (10 psi) gage. Close valves and disconnect refrigerant drum. Test system for leaks with halide test torch or other approved method suitable for the test gas used. Repair all leaking joints and retest.
2. Connect a drum of dry nitrogen to charging valve and bring test pressure to design pressure for low side and for high side. Test entire system again for leaks.

3. Evacuate the entire refrigerant system by the triplicate evacuation method with a vacuum pump equipped with an electronic gage reading in mPa (microns). Pull the system down to 665 mPa (500 microns) and hold for four hours then break the vacuum with dry nitrogen (or refrigerant). Repeat the evacuation two more times breaking the third vacuum with the refrigeration to be charged and charge with the proper volume of refrigerant.

3.6 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

B. Components provided under this section of the specification will be tested as part of a larger system.

3.7 DEMONSTRATION AND TRAINING

A. Training on components provided under this section will be provided as part of other systems.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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SECTION 23 25 00
HVAC WATER TREATMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies cleaning and treatment of circulating HVAC water systems, including the following.
   1. Cleaning compounds.
   2. Chemical treatment for closed loop heat transfer systems.

B. Provide water treatment for any new or modified closed loop heat transfer systems, including but not limited to chilled water, condenser water, heating hot water, and glycol water systems.
   1. Generally, existing water treatment systems shall be re-used. Contractor shall provide new treatment chemicals.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.

C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

D. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

E. Section 23 21 13, HYDRONIC PIPING.

1.3 QUALITY ASSURANCE

A. Refer to paragraph, QUALITY ASSURANCE in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

B. Technical Services: Provide the services of an experienced water treatment chemical engineer or technical representative to direct flushing, cleaning, pre-treatment, training, debugging, and acceptance testing operations; direct and perform chemical limit control during construction period and monitor systems for a period of 12 months after acceptance, including not less than 6 service calls and written status reports. Emergency calls are not included. Minimum service during construction/start-up shall be 4 hours.

C. Chemicals: Chemicals shall be non-toxic approved by local authorities and meeting applicable EPA requirements.

1.4 SUBMITTALS

A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.

B. Manufacturer's Literature and Data including:

1. Cleaning compounds and recommended procedures for their use.
2. Chemical treatment for closed systems, including installation and operating instructions.
3. Glycol-water system materials, equipment, and installation.

C. Materials Safety Data Sheet for all proposed chemical compounds, based on U.S. Department of Labor Form No. L5B-005-4.

D. Maintenance and operating instructions in accordance with Section 01 00 00, GENERAL REQUIREMENTS.

1.5 APPLICABLE PUBLICATIONS

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

B. National Fire Protection Association (NFPA):

1. 70-2020 National Electric Code (NEC)

C. American Society for Testing and Materials (ASTM):

1. F441/F441M-02 (2008) Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80

1.6 AS-BUILT DOCUMENTATION

A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC for as-built documentation requirements.

PART 2 - PRODUCTS

2.1 CLEANING COMPOUNDS

A. Alkaline phosphate or non-phosphate detergent/surfactant specific to remove organic soil, hydrocarbons, flux, pipe mill varnish, pipe compounds, iron oxide, and like deleterious substances, with or without inhibitor, suitable for system wetted metals without deleterious effects.

B. All chemicals to be acceptable for discharge to sanitary sewer.

C. Refer to Section 23 21 13, HYDRONIC PIPING, PART 3, for flushing and cleaning procedures.

2.2 CHEMICAL TREATMENT FOR CLOSED LOOP SYSTEMS

A. Inhibitor: Provide sodium nitrite/borate, molybdate-based inhibitor or other approved compound suitable for make-up quality and make-up rate and which will cause or enhance bacteria/corrosion problems or mechanical seal failure due to excessive total dissolved solids. Shot feed manually. Maintain inhibitor residual as determined by water treatment laboratory, taking into consideration residual and temperature effect on pump mechanical seals.

B. pH Control: Inhibitor formulation shall include adequate buffer to maintain pH range of 8.0 to 10.5.

C. Performance: Protect various wetted, coupled, materials of construction including ferrous, and red and yellow metals. Maintain system essentially free of scale, corrosion, and fouling. Corrosion rate of following metals shall not exceed specified mills per year penetration; ferrous, 0-2; brass, 0-1; copper, 0-1. Inhibitor shall be stable at equipment skin surface temperatures and bulk water temperatures of not less than 121 degrees C (250 degrees F) and 52 degrees C (125 degrees Fahrenheit) respectively. Heat exchanger fouling and capacity reduction shall not exceed that allowed by fouling factor 0.0005.

D. Pot Feeder: Bypass type, complete with necessary shut off valves, drain and air release valves, and system connections, for introducing chemicals into system, cast iron or steel tank with funnel or large opening on top for easy chemical addition. Feeders shall be 18.9 L (five gallon) minimum capacity at 860 kPa (125 psig) minimum working pressure.

E. Chemical Feed System: Re-use existing water treatment feed system.

2.3 EQUIPMENT AND MATERIALS IDENTIFICATION

A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Delivery and Storage: Deliver all chemicals in manufacturer's sealed shipping containers. Store in designated space and protect from deleterious exposure and hazardous spills.

B. Install equipment furnished by the chemical treatment supplier and charge systems according to the manufacturer's instructions and as directed by the Technical Representative.

C. Refer to Section 23 21 13, HYDRONIC PIPING for chemical treatment piping, installed as follows:

1. Provide a bypass line around water meters and bleed off piping assembly. Provide ball valves to allow for bypassing, isolation, and servicing of components.
2. Provide installation supervision, start-up and operating instruction by manufacturer's technical representative.

D. Before adding cleaning chemical to the closed system, all air handling coils and fan coil units should be isolated by closing the inlet and outlet valves and opening the bypass valves. This is done to prevent dirt and solids from lodging the coils.

E. Do not valve in or operate system pumps until after system has been cleaned.

F. After chemical cleaning is satisfactorily completed, open the inlet and outlet valves to each coil and close the bypass valves. Also, clean all strainers.

G. Perform tests and report results in accordance with Section 01 00 00, GENERAL REQUIREMENTS.

H. After cleaning is complete, and water PH is acceptable to manufacturer of water treatment chemical, add manufacturer-recommended amount of chemicals to systems.

3.2 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

B. Components provided under this section of the specification will be tested as part of a larger system.

3.3 DEMONSTRATION AND TRAINING

A. Provide two hours of instruction to VA personnel in operation and maintenance of the system.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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SECTION 23 31 00
HVAC DUCTS AND CASINGS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Ductwork and accessories for HVAC including the following:
   1. Supply Air, Return Air, Outside Air, Exhaust, Make-up Air, and Relief systems.
   2. Duct cleaning.

B. Definitions:
   1. SMACNA Standards as used in this specification means the HVAC Duct Construction Standards, Metal and Flexible.
   2. Seal or Sealing: Use of liquid or mastic sealant, with or without compatible tape overlay, or gasketing of flanged joints, to keep air leakage at duct joints, seams and connections to an acceptable minimum.
   3. Duct Pressure Classification: SMACNA HVAC Duct Construction Standards, Metal and Flexible.
   4. Exposed Duct: Exposed to view in a finished room.

1.2 RELATED WORK

A. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
B. Section 07 84 00, JOINT FIRESTOPPING.
C. Section 07 84 13, PENETRATION FIRESTOPPING.
D. Section 08 90 00, LOUVERS AND VENTS.
E. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.
F. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
G. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.
H. Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC.
I. Section 23 07 11, HVAC AND BOILER PLANT INSULATION.
J. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
K. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
L. Section 23 34 00, HVAC FANS.
M. Section 23 37 00, AIR INLETS AND OUTLETS.

N. Section 23 81 00, DECENTRALIZED UNITARY HVAC EQUIPMENT.

O. Section 23 81 23, COMPUTER-ROOM AIR CONDITIONERS.

P. Section 23 81 45, VARIABLE REFRIGERANT FLOW SYSTEMS.

1.3 QUALITY ASSURANCE

A. Refer to article, QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

B. Fire Safety Code: Comply with NFPA 90A.

C. Duct System Construction and Installation: Referenced SMACNA Standards are the minimum acceptable quality.

D. Duct Sealing, Air Leakage Criteria, and Air Leakage Tests: Ducts shall be sealed as per duct sealing requirements of SMACNA HVAC Air Duct Leakage Test Manual for duct pressure classes shown on the drawings.

E. Duct accessories exposed to the air stream, such as dampers of all types (except smoke dampers) and access openings, shall be of the same material as the duct or provide at least the same level of corrosion resistance.

1.4 SUBMITTALS

A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.

B. Manufacturer's Literature and Data:

1. Rectangular ducts:
    a. Schedules of duct systems, materials and selected SMACNA construction alternatives for joints, sealing, gage and reinforcement.
    b. Duct liner.
    c. Sealants and gaskets.
    d. Access doors.
2. Round and flat oval duct construction details:
    a. Manufacturer's details for duct fittings.
    b. Duct liner.
    c. Sealants and gaskets.
    d. Access sections.
    e. Installation instructions.
3. Volume dampers, back draft dampers.

4. Upper hanger attachments.
5. Fire dampers, fire doors, and smoke dampers with installation instructions.
6. Flexible ducts and clamps, with manufacturer's installation instructions.
7. Flexible connections.
8. Instrument test fittings.
9. Details and design analysis of alternate or optional duct systems.

C. Coordination Drawings: Refer to article, SUBMITTALS, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

D. Test results.

1.5 APPLICABLE PUBLICATIONS

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

B. American Society of Civil Engineers (ASCE):
1. ASCE7-2017 Minimum Design Loads for Buildings and Other Structures

C. American Society for Testing and Materials (ASTM):
1. A167-2009 Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
2. A653-2019 Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy coated (Galvannealed) by the Hot-Dip process
3. A1011-2018 Standard Specification for Steel, Sheet and Strip, Hot rolled, Carbon, structural, High-Strength Low-Alloy, High Strength Low-Alloy with Improved Formability, and Ultra-High Strength
4. B209-2014 Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
5. C1071-2019 Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)
6. E84-2014 Standard Test Method for Surface Burning Characteristics of Building Materials

D. National Fire Protection Association (NFPA):
1. 90A-2018 Standard for the Installation of Air Conditioning and Ventilating Systems

2. 96-2018 Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations

E. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):
1. 3rd Edition - 2006 HVAC Duct Construction Standards, Metal and Flexible
2. 2nd Edition - 2012 HVAC Air Duct Leakage Test Manual
3. 6th Edition - 2016 Fibrous Glass Duct Construction Standards

F. Underwriters Laboratories, Inc. (UL):
1. 181-2013 Factory-Made Air Ducts and Air Connectors
2. 555-2006 Standard for Fire Dampers
3. 555S-2014 Standard for Smoke Dampers

PART 2 - PRODUCTS

2.1 DUCT MATERIALS AND SEALANTS

A. General: Except for systems specified otherwise, construct ducts, casings, and accessories of galvanized sheet steel, ASTM A653, coating G90; or, aluminum sheet, ASTM B209, alloy 1100, 3003 or 5052.

B. Joint Sealing: Refer to SMACNA HVAC Duct Construction Standards.
1. Sealant: Elastomeric compound, gun or brush grade, maximum 25 flame spread and 50 smoke developed (dry state) compounded specifically for sealing ductwork as recommended by the manufacturer. Generally provide liquid sealant, with or without compatible tape, for low clearance slip joints and heavy, permanently elastic, mastic type where clearances are larger. Oil base caulking and glazing compounds are not acceptable because they do not retain elasticity and bond.
2. Tape: Use only tape specifically designated by the sealant manufacturer and apply only over wet sealant. Pressure sensitive tape shall not be used on bare metal or on dry sealant.
3. Gaskets in Flanged Joints: Soft neoprene.

C. Approved factory-made joints may be used.

2.2 DUCT CONSTRUCTION AND INSTALLATION

A. Regardless of the pressure classifications outlined in the SMACNA Standards, fabricate and seal all ductwork in accordance with the following minimum pressure and sealing classifications (except where specifically noted otherwise on the drawings): 0 to 50 mm (2 inch) pressure rating, Class A sealing.

B. Round and Flat Oval Ducts: Furnish duct and fittings made by the same manufacturer to insure good fit of slip joints. When submitted and approved in advance, round and flat oval duct, with size converted on the basis of equal pressure drop, may be furnished in lieu of rectangular duct design shown on the drawings.

1. Elbows: Diameters 80 through 200 mm (3 through 8 inches) shall be two sections die stamped, all others shall be gored construction, maximum 18 degree angle, with all seams continuously welded or standing seam. Coat galvanized areas of fittings damaged by welding with corrosion resistant aluminum paint or galvanized repair compound.
2. Provide bell mouth, conical tees or taps, laterals, reducers, and other low loss fittings as shown in SMACNA HVAC Duct Construction Standards.
3. Ribbed Duct Option: Lighter gage round/oval duct and fittings may be furnished provided certified tests indicating that the rigidity and performance is equivalent to SMACNA standard gage ducts are submitted.
    a. Ducts: Manufacturer's published standard gage, G90 coating, spiral lock seam construction with an intermediate standing rib.
    b. Fittings: May be manufacturer's standard as shown in published catalogs, fabricated by spot welding and bonding with neoprene base cement or machine formed seam in lieu of continuous welded seams.
4. Provide flat side reinforcement of oval ducts as recommended by the manufacturer and SMACNA HVAC Duct Construction Standard S3.13. Because of high pressure loss, do not use internal tie-rod reinforcement unless approved by the COR.

C. Volume Dampers: Single blade or opposed blade, multi-louver type as detailed in SMACNA Standards. Refer to SMACNA Duct Construction Standards Figure 2-12 for Single Blade and Figure 2.13 for Multi-blade Volume Dampers.

D. Duct Hangers and Supports: Refer to SMACNA Standards Section IV. Avoid use of trapeze hangers for round duct.

2.3 DUCT LINER

A. Duct sizes shown on drawings for lined duct are clear opening inside lining.

B. Duct lining shall be applied with mechanical fasteners and 100 percent coverage of adhesive in conformance with SMACNA Duct Liner Application Standard.

2.4 DUCT ACCESS DOORS, PANELS AND SECTIONS

A. Provide access doors, sized and located for maintenance work, upstream, in the following locations:

1. Each fire damper (for link service), smoke damper and automatic control damper.
2. Each duct mounted smoke detector.

B. Openings shall be as large as feasible in small ducts, 300 mm by 300 mm (12 inch by 12 inch) minimum where possible. Access sections in insulated ducts shall be double-wall, insulated. Transparent shatterproof covers are preferred for uninsulated ducts.

1. For rectangular ducts: Refer to SMACNA HVAC Duct Construction Standards (Figure 2-12).
2. For round and flat oval duct: Refer to SMACNA HVAC duct Construction Standards (Figure 2-11).

2.5 FIRE DAMPERS

A. Galvanized steel, interlocking blade type, UL listing and label, 1-1/2-hour rating, 70 degrees C (160 degrees F) fusible line, 100 percent free opening with no part of the blade stack or damper frame in the air stream.

B. Fire dampers in wet air exhaust shall be of stainless steel construction, all others may be galvanized steel.

C. Minimum requirements for fire dampers:

1. The damper frame may be of design and length as to function as the mounting sleeve, thus eliminating the need for a separate sleeve, as allowed by UL 555. Otherwise provide sleeves and mounting angles, minimum 1.9 mm (14 gage), required to provide installation equivalent to the damper manufacturer's UL test installation.
2. Submit manufacturer's installation instructions conforming to UL rating test.

2.6 SMOKE DAMPERS

A. Maximum air velocity, through free area of open damper, and pressure loss: Low pressure and medium pressure duct (supply, return, exhaust, outside air): 450 m/min (1500 fpm). Maximum static pressure loss: 32 Pa (0.13 inch W.G.).

B. Maximum air leakage, closed damper: 0.32 cubic meters /min/square meter (4.0 CFM per square foot) at 750 Pa (3 inch W.G.) differential pressure.

C. Minimum requirements for dampers:
   1. Shall comply with requirements of Table 6-1 of UL 555S, except for the Fire Endurance and Hose Stream Test.
   2. Frame: Galvanized steel channel with side, top and bottom stops or seals.
   3. Blades: Galvanized steel, parallel type preferably, 300 mm (12 inch) maximum width, edges sealed with neoprene, rubber or felt, if required to meet minimum leakage. Airfoil (streamlined) type for minimum noise generation and pressure drop are preferred for duct mounted dampers.
   4. Shafts: Galvanized steel.
   5. Bearings: Nylon, bronze sleeve or ball type.
   6. Hardware: Zinc plated.
   7. Operation: Automatic open/close. No smoke damper that requires manual reset or link replacement after actuation is acceptable. See drawings for required control operation.

D. Motor operator (actuator): Provide pneumatic or electric as required by the automatic control system, externally mounted on stand-offs to allow complete insulation coverage.

2.7 COMBINATION FIRE AND SMOKE DAMPERS

A. Combination fire and smoke dampers: Multi-blade type units meeting all requirements of both fire dampers and smoke dampers shall be used where shown and may be used at the Contractor's option where applicable.

2.8 FLEXIBLE AIR DUCT

A. General: Factory fabricated, complying with NFPA 90A for connectors not passing through floors of buildings. Flexible ducts shall not penetrate any fire or smoke barrier which is required to have a fire resistance rating of one hour or more. Flexible duct length shall not exceed 1.5 m (5 feet). Provide insulated acoustical air duct connectors in supply air duct systems and elsewhere as shown.

B. Flexible ducts shall be listed by Underwriters Laboratories, Inc., complying with UL 181. Ducts larger than 200 mm (8 inches) in diameter shall be Class 1. Ducts 200 mm (8 inches) in diameter and smaller may be Class 1 or Class 2.

C. Insulated Flexible Air Duct: Factory made including mineral fiber insulation with maximum C factor of 0.25 at 24 degrees C (75 degrees F) mean temperature, encased with a low permeability moisture barrier outer jacket, having a puncture resistance of not less than 50 Beach Units. Acoustic insertion loss shall not be less than 3 dB per 300 mm (foot) of straight duct, at 500 Hz, based on 150 mm (6 inch) duct, of 750 m/min (2500 fpm).

D. Application Criteria:

1. Temperature range: -18 to 93 degrees C (0 to 200 degrees F) internal.
2. Maximum working velocity: 1200 m/min (4000 feet per minute).
3. Minimum working pressure, inches of water gage: 2500 Pa (10 inches) positive, 500 Pa (2 inches) negative.

E. Duct Clamps: 100 percent nylon strap, 80 kg (175 pounds) minimum loop tensile strength manufactured for this purpose or stainless steel strap with cadmium plated worm gear tightening device. Apply clamps with sealant and as approved for UL 181, Class 1 installation.

2.9 FLEXIBLE DUCT CONNECTIONS

A. Where duct connections are made to fans, air terminal units, and air handling units, install a non-combustible flexible connection of 822 g (29 ounce) neoprene coated fiberglass fabric approximately 150 mm (6 inches) wide. For connections exposed to sun and weather provide hypalon coating in lieu of neoprene. Burning characteristics shall conform to NFPA 90A. Securely fasten flexible connections to round ducts with stainless steel or zinc-coated iron draw bands with worm gear fastener. For rectangular connections, crimp fabric to sheet metal and fasten sheet metal to ducts by screws 50 mm (2 inches) on center. Fabric shall not be stressed other than by air pressure. Allow at least 25 mm (one inch) slack to ensure that no vibration is transmitted.

2.10 FIRESTOPPING MATERIAL

A. Refer to Section 07 84 00, FIRESTOPPING.

2.11 SEISMIC RESTRAINT FOR DUCTWORK

A. Refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

2.12 INSTRUMENT TEST FITTINGS

A. Manufactured type with a minimum 50 mm (two inch) length for insulated duct, and a minimum 25 mm (one inch) length for duct not insulated. Test hole shall have a flat gasket for rectangular ducts and a concave gasket for round ducts at the base, and a screw cap to prevent air leakage.

B. Provide instrument test holes at each duct or casing mounted temperature sensor or transmitter, and at entering and leaving side of each heating coil, cooling coil, and heat recovery unit.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with provisions of Section 23 05 11, COMMON WORK RESULTS FOR HVAC, particularly regarding coordination with other trades and work in existing buildings.

B. Fabricate and install ductwork and accessories in accordance with referenced SMACNA Standards:
   1. Drawings show the general layout of ductwork and accessories but do not show all required fittings and offsets that may be necessary to connect ducts to equipment, boxes, diffusers, grilles, etc., and to coordinate with other trades. Fabricate ductwork based on field measurements. Provide all necessary fittings and offsets at no additional cost to the government. Coordinate with other trades for space available and relative location of HVAC equipment and accessories on ceiling grid. Duct sizes on the drawings are inside dimensions which shall be altered by Contractor to other dimensions with the same air handling characteristics where necessary to avoid interferences and clearance difficulties.
   2. Provide duct transitions, offsets and connections to dampers, coils, and other equipment in accordance with SMACNA Standards. Provide streamliner, when an obstruction cannot be avoided and must be taken in by a duct. Repair galvanized areas with galvanizing repair compound.
   3. Provide bolted construction and tie-rod reinforcement in accordance with SMACNA Standards.
   4. Construct casings, eliminators, and pipe penetrations in accordance with SMACNA Standards. Design casing access doors to swing against air pressure so that pressure helps to maintain a tight seal.

C. Install duct hangers and supports in accordance with SMACNA Standards.

D. Install fire dampers, smoke dampers, and combination fire/smoke dampers in accordance with the manufacturer's instructions to conform to the installation used for the rating test. Install fire dampers, smoke dampers, and combination fire/smoke dampers at locations indicated and where ducts penetrate fire rated and/or smoke rated walls, shafts and where required by the COR. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges per UL and NFPA. Demonstrate re-setting of fire dampers and operation of smoke dampers to the COR.

E. Seal openings around duct penetrations of floors and fire rated partitions with fire stop material as required by NFPA 90A.

F. Flexible duct installation:

1. Refer to SMACNA Standards, Chapter 3.
2. Ducts shall be continuous, single pieces not over 1.5 m (5 feet) long (NFPA 90A), adequately supported. Centerline radius of bends shall be not less than two duct diameters. Make connections with clamps as recommended by SMACNA. Clamp per SMACNA with one clamp on the core duct and one on the insulation jacket.
3. Flexible ducts shall not penetrate floors, or any chase or partition designated as a fire or smoke barrier, including one-hour or two-hour fire-rated corridor partitions.
4. Support ducts per SMACNA Standards.
5. Provide 5' of flexible duct for each connection to air inlets & outlets in hard lid or T-bar ceilings in offices, consultation rooms, treatment rooms, and all acoustically sensitive spaces. Flexible duct shall be installed coiled or with multiple bends to discourage sound transmission through the duct system.

G. Where diffusers, registers and grilles cannot be installed to avoid seeing inside the duct, paint the inside of the duct with flat black paint to reduce visibility.

H. Control Damper Installation:

1. Provide necessary blank-off plates required to install dampers that are smaller than duct size. Provide necessary transitions required to install dampers larger than duct size.

2. Assemble multiple sections dampers with required interconnecting linkage and extend required number of shafts through duct for external mounting of damper motors.
3. Provide necessary sheet metal baffle plates to eliminate stratification and provide air volumes specified. Locate baffles by experimentation, and affix and seal permanently in place, only after stratification problem has been eliminated.
4. Install all damper control/adjustment devices on stand-offs to allow complete coverage of insulation.

I. Low Pressure Duct Liner: Install in accordance with SMACNA, Duct Liner Application Standard.

J. Protection and Cleaning: Adequately protect equipment and materials against physical damage. Place equipment in first class operating condition or return to source of supply for repair or replacement, as determined by COR. Protect equipment and ducts during construction against entry of foreign matter to the inside and clean both inside and outside before operation and painting. When new ducts are connected to existing ductwork, clean both new and existing ductwork by mopping and vacuum cleaning inside and outside before operation.

3.2 DUCT LEAKAGE TESTS AND REPAIR

A. Ductwork leakage testing shall be performed by the Testing and Balancing Contractor directly contracted by the General Contractor and independent of the Sheet Metal Contractor.

B. Ductwork leakage testing shall be performed for the entire air distribution system (including all supply, return, exhaust, relief, makeup air, and outside air ductwork), section by section, including fans, coils and filter sections.

1. Based upon satisfactory initial duct leakage test results, the scope of the testing may be reduced by the COR on ductwork constructed to the 500 Pa (2" WG) duct pressure classification. In no case shall the leakage testing of ductwork constructed above the 500 Pa (2" WG) duct pressure classification or ductwork located in shafts or other inaccessible areas be eliminated.

C. Test procedure, apparatus and report shall conform to SMACNA Leakage Test manual. The maximum leakage rate allowed is 4 percent of the design air flow rate.
D. All ductwork shall be leak tested first before enclosed in a shaft or covered in other inaccessible areas.
E. All tests shall be performed in the presence of the COR and the Test and Balance agency. The Test and Balance agency shall measure and record duct leakage and report to the COR and identify leakage source with excessive leakage.
F. If any portion of the duct system tested fails to meet the permissible leakage level, the Contractor shall rectify sealing of ductwork to bring it into compliance and shall retest it until acceptable leakage is demonstrated to the COR.
G. All tests and necessary repairs shall be completed prior to insulation or concealment of ductwork.
H. Make sure all openings used for testing flow and temperatures by TAB Contractor are sealed properly.

3.3 TESTING, ADJUSTING AND BALANCING (TAB)

A. Refer to Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.

3.4 OPERATING AND PERFORMANCE TESTS

A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

3.5 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.
B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

3.6 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer’s technical representative for one hour to instruct VA personnel in operation and maintenance of units.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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SECTION 23 34 00
HVAC FANS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Fans for heating, ventilating and air conditioning.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.
B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
C. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.
D. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
E. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT.
F. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
G. Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.
H. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

1.3 QUALITY ASSURANCE

A. Refer to paragraph, QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.
B. Fans and power ventilators shall be listed in the current edition of AMCA 26l, and shall bear the AMCA performance seal.
C. Operating Limits for Centrifugal Fans: AMCA 99 (Class I, II, and III).
D. Fans and power ventilators shall comply with the following standards:
    1. Testing and Rating: AMCA 210.
    2. Sound Rating: AMCA 300.
E. Vibration Tolerance for Fans and Power Ventilators: Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
F. Performance Criteria:
    1. The fan schedule shall show the design air volume and static pressure. Select the fan motor HP by increasing the fan BHP by 10 percent to account for the drive losses and field conditions.
    2. Select the fan operating point as follows:

a. Forward Curve and Axial Flow Fans: Right hand side of peak pressure point
b. Air Foil, Backward Inclined, or Tubular: At or near the peak static efficiency

G. Safety Criteria: Provide manufacturer's standard screen on fan inlet and discharge where exposed to operating and maintenance personnel.

H. Corrosion Protection:

1. Except for fans in fume hood exhaust service, all steel shall be mill-galvanized, or phosphatized and coated with minimum two coats, corrosion resistant enamel paint. Manufacturers paint and paint system shall meet the minimum specifications of: ASTM D1735 water fog; ASTM B117 salt spray; ASTM D3359 adhesion; and ASTM G152 and G153 for carbon arc light apparatus for exposure of non-metallic material.
2. Fans for general purpose fume hoods, or chemical hoods, and radioisotope hoods shall be constructed of materials compatible with the chemicals being transported in the air through the fan.

I. Spark resistant construction: If flammable gas, vapor or combustible dust is present in concentrations above 20% of the Lower Explosive Limit (LEL), the fan construction shall be as recommended by AMCA's Classification for Spark Resistant Construction. Drive set shall be comprised of non-static belts for use in an explosive.

1.4 SUBMITTALS

A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.

B. Manufacturers Literature and Data:

1. Fan sections, motors and drives.
2. Centrifugal fans, motors, drives, accessories and coatings.
   a. In-line centrifugal fans.
3. Power roof and wall ventilators.

C. Certified Sound power levels for each fan.

D. Motor ratings types, electrical characteristics and accessories.

E. Belt guards.

F. Maintenance and Operating manuals in accordance with Section 01 00 00, GENERAL REQUIREMENTS.

G. Certified fan performance curves for each fan showing cubic feet per minute (CFM) versus static pressure, efficiency, and horsepower for design point of operation.

1.5 APPLICABLE PUBLICATIONS

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

B. Air Movement and Control Association International, Inc. (AMCA):
   1. Standards Handbook
   2. 99-0401 Classification for Spark Resistant Construction
   3. 2l0-06 Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
   4. 26l-09 Directory of Products Licensed to bear the AMCA Certified Ratings Seal - Published Annually
   5. 300-08 Reverberant Room Method for Sound Testing of Fans

C. American Society for Testing and Materials (ASTM):
   1. B117-07a Standard Practice for Operating Salt Spray (Fog) Apparatus
   2. D1735-08 Standard Practice for Testing Water Resistance of Coatings Using Water Fog Apparatus
   3. D3359-08 Standard Test Methods for Measuring Adhesion by Tape Test
   4. G152-06 Standard Practice for Operating Open Flame Carbon Arc Light Apparatus for Exposure of Non-Metallic Materials
   5. G153-04 Standard Practice for Operating Enclosed Carbon Arc Light Apparatus for Exposure of Non-Metallic Materials

D. Underwriters Laboratories, Inc. (UL):
   1. 181-2005 Factory Made Air Ducts and Air Connectors

1.6 EXTRA MATERIALS

A. Provide one additional set of belts for all belt-driven fans.

PART 2 - PRODUCTS

2.1 CENTRIFUGAL FANS

A. Standards and Performance Criteria: Refer to Paragraph, QUALITY ASSURANCE. Record factory vibration test results on the fan or furnish to the Contractor.

B. Construction: Wheel diameters and outlet areas shall be in accordance with AMCA standards.

1. Housing: Low carbon steel, arc welded throughout, braced and supported by structural channel or angle iron to prevent vibration or pulsation, flanged outlet, inlet fully streamlined. Provide lifting clips, and casing drain. Provide manufacturer's standard access door. Provide 12.5 mm (1/2 inches) wire mesh screens for fan inlets without duct connections.
2. Wheel: Steel plate with die formed blades welded or riveted in place, factory balanced statically and dynamically.
3. Shaft: Designed to operate at no more than 70 percent of the first critical speed at the top of the speed range of the fans class.
4. Bearings: Heavy duty ball or roller type sized to produce a B10 life of not less than 50,000 hours, and an average fatigue life of 200,000 hours. Extend filled lubrication tubes for interior bearings or ducted units to outside of housing.
5. Belts: Oil resistant, non-sparking and non-static.
6. Belt Drives: Factory installed with final alignment belt adjustment made after installation.
7. Motors and Fan Wheel Pulleys: Adjustable pitch for use with motors through 15HP, fixed pitch for use with motors larger than 15HP. Select pulleys so that pitch adjustment is at the middle of the adjustment range at fan design conditions.
8. Motor, adjustable motor base, drive and guard: Furnish from factory with fan. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION for specifications. Provide protective sheet metal enclosure for fans located outdoors.

9. Furnish variable speed fan motor controllers where shown on the drawings. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION for controller/motor combination requirements.

C. In-line Centrifugal Fans: In addition to the requirements of paragraphs A and 2.2.B.3 thru 2.2.B.9, provide minimum 18 Gauge galvanized steel housing with inlet and outlet flanges, backward inclined aluminum centrifugal fan wheel, bolted access door and supports as required. Motors shall be factory pre-wired to an external junction box. Provide factory wired disconnect switch.

2.2 POWER ROOF VENTILATOR

A. Standards and Performance Criteria: Refer to Paragraph, QUALITY ASSURANCE.

B. Type: Centrifugal fan, backward inclined blades. Provide down-blast or up-blast type as indicated.

C. Construction: Steel or aluminum, completely weatherproof, for curb mounting, exhaust cowl or entire drive assembly readily removable for servicing, aluminum bird screen on discharge, UL approved safety disconnect switch, conduit for wiring, vibration isolators for wheel, motor and drive assembly. Provide self acting back draft damper.

D. Motor and Drive: Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION. Bearings shall be pillow block ball type with a minimum L-50 life of 200,000 hours. Motor shall be located out of air stream.

E. Roof Curbs:

1. Provide fans with prefabricated roof curbs.
2. Roof curbs shall be configured to match roof slope at each fan location.
3. Roof curbs shall be be configured to position base of fan a minimum of 18 inches above surrounding roof.

F. Up-blast Type: Top discharge exhauster, motor out of air stream.

1. For kitchen hood exhaust applications, provide grease trough on base and threaded drain. The mounting height of the kitchen up-blast exhaust fan shall be in compliance with NFPA 96.

2. Provide vented curb extension for kitchen hood exhaust applications.

2.3 POWER WALL VENTILATOR

A. Standards and Performance Criteria: Refer to Paragraph, QUALITY ASSURANCE.

B. Type: Centrifugal fan, backward inclined blades.

C. Construction: Steel or aluminum, completely weatherproof, for wall mounting, exhaust cowl or entire drive assembly readily removable for servicing, aluminum bird screen on discharge, UL approved safety disconnect switch, conduit for wiring, vibration isolators for wheel, motor and drive assembly. Provide self acting back draft damper.

D. Motor and Drive: Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION. Bearings shall be pillow block ball type with a minimum L-50 life of 200,000 hours. Motor shall be located out of air stream.

2.4 PREFABRICATED ROOF CURBS

A. Roof curbs shall be configured to match roof slope at each fan location.

B. Roof curbs shall be be configured to locate fan base a minimum of 18 inches above surrounding roof.

C. Provide vented curb extension for kitchen hood exhaust applications, sized to locate fan discharge a minimum of 48 inches above surrounding roof.

D. Provide curbs with continuously welded seams, built-in cant strips, interior baffle with acoustic insulation, curb bottoms, and hinged curb adapters.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install fan, motor and drive in accordance with manufacturer's instructions.

B. Align fan and motor sheaves to allow belts to run true and straight.

C. Bolt equipment to curbs with galvanized lag bolts.

D. Install vibration control devices as shown on drawings and specified in Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.

3.2 PRE-OPERATION MAINTENANCE

A. Lubricate bearings, pulleys, belts and other moving parts with manufacturer recommended lubricants.

B. Rotate impeller by hand and check for shifting during shipment and check all bolts, collars, and other parts for tightness.

C. Clean fan interiors to remove foreign material and construction dirt and dust.

3.3 EQUIPMENT START-UP

A. Verify operation of motor, drive system and fan wheel according to the drawings and specifications.

B. Check vibration and correct as necessary for air balance work.

C. After air balancing is complete and permanent sheaves are in place perform necessary field mechanical balancing to meet vibration tolerance in Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.

3.4 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.

B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

3.5 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer' s technical representative for two hours to instruct VA personnel in operation and maintenance of units.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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SECTION 23 37 00
AIR OUTLETS AND INLETS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Air Outlets and Inlets: Diffusers, Registers, and Grilles.

1.2 RELATED WORK

A. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
B. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.
C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
D. Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.
E. Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.
F. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

1.3 QUALITY ASSURANCE

A. Refer to Article, QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
B. Fire Safety Code: Comply with NFPA 90A.

1.4 SUBMITTALS

A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
B. Manufacturer's Literature and Data:
   1. Air intake/exhaust hoods.
   2. Diffusers, registers, grilles and accessories.
C. Coordination Drawings: Refer to Article, SUBMITTALS, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

1.5 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
B. Air Diffusion Council Test Code:
   1. 1062 GRD-2015 Certification, Rating, and Test Manual 4th Edition
C. American Society of Civil Engineers (ASCE):

1. ASCE7-2017 Minimum Design Loads for Buildings and Other Structures

D. American Society for Testing and Materials (ASTM):
   1. B209-2014 Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate

E. National Fire Protection Association (NFPA):
   1. 90A-2018 Standard for the Installation of Air Conditioning and Ventilating Systems

F. Underwriters Laboratories, Inc. (UL):
   1. 181-2013 UL Standard for Safety Factory-Made Air Ducts and Connectors

PART 2 - PRODUCTS

2.1 EQUIPMENT SUPPORTS

A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

2.2 AIR OUTLETS AND INLETS

A. Materials:
   1. Aluminum, Extruded: ASTM B221M (B221).
   2. Aluminum, Plate and Sheet: ASTM B209M (B209); alloy 3003 or 5005 with temper as required for forming.
   3. Provide all air inlets & outlets with manufacturer's standard gasket.

B. Fasteners
   1. Exposed Fastenings:
      a. Fasteners for aluminum inlets & outlets shall be stainless steel.

C. Contractor shall review all ceiling drawings and details and provide all ceiling mounted devices with appropriate dimensions and trim for the specific locations.

D. Performance Test Data: In accordance with Air Diffusion Council Code 1062GRD. Refer to Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT for NC criteria.

E. Air Supply Outlets:

1. Ceiling Diffusers: Suitable for surface mounting, exposed T bar or special tile ceilings, natural aluminum finish, square or round neck connection as shown on the drawings. Provide plaster frame for units in plaster ceilings.
   a. Square, louver, fully adjustable pattern: Round neck, surface mounting unless shown otherwise on the drawings. Provide equalizing or control grid and volume control damper.
   b. Louver face type: Square or rectangular, removable core for 1, 2, 3, or 4 way directional pattern. Provide equalizing or control grid and opposed blade damper.
   c. Perforated face type: Manual adjustment for one-, two-, three-, or four-way horizontal air distribution pattern without change of air volume or pressure. Provide equalizing or control grid and opposed blade over overlapping blade damper. Perforated face diffusers for VAV systems shall have the pattern controller on the inner face, rather than in the neck and designed to discharge air horizontally at the ceiling maintaining a Coanda effect.

F. Return and Exhaust Registers and Grilles:
   1. Provide opposed blade damper without removable key operator for registers.
   2. Finish
      a. Manufacturer's standard aluminum finish for duct-mounted units.
   3. Standard Type: Fixed horizontal face bars set at 30 to 45 degrees, approximately 30 mm (1 1/4 inch) margin.

PART 3 - EXECUTION

2.1 INSTALLATION

A. Comply with provisions of Section 23 05 11, COMMON WORK RESULTS FOR HVAC, particularly regarding coordination with other trades and work in existing buildings.

B. Protection and Cleaning: Protect equipment and materials against physical damage. Place equipment in first class operating condition, or return to source of supply for repair or replacement, as determined by COR. Protect equipment during construction against entry of foreign matter to the inside and clean both inside and outside before operation and painting.

2.2 TESTING, ADJUSTING AND BALANCING (TAB)

A. Refer to Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.

2.3 OPERATING AND PERFORMANCE TESTS

A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

2.4 START-UP AND INSTRUCTIONS

A. Check vibration and correct as necessary for air balance work.

B. After air balancing is complete and permanent sheaves are in place perform necessary field mechanical balancing to meet vibration tolerance in Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.

2.5 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.

B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

2.6 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer' s technical representative for four hours to instruct VA personnel in operation and maintenance of units.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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SECTION 23 81 00
DECENTRALIZED UNITARY HVAC EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies packaged heat recovery ventilators and mini-split systems.

B. Definitions:

1. Energy Efficiency Ratio (EER): The ratio of net cooling capacity is Btu/h to total rate of electricity input in watts under designated operating conditions (Btu hour/Watt).
2. Energy Recovery Ventilator (ERV): An air-to-air heat exchanger that not only transfers sensible heat but also latent heat, and may be packaged with supply and/or exhaust fans.
3. Seasonal Energy Efficiency Ratio (SEER): The ratio of the total cooling output of an air conditioner during its normal annual usage period for cooling in Btu/h divided by total electric energy input in watts during the same period (Btu hour/Watt).
4. Unitary: A Unitary Air Conditioner consists of one or more factory-made assemblies which normally include an evaporator or cooling coil, a compressor and condenser combination, and may include a heating function as well.

1.2 RELATED WORK

A. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
B. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
C. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC.
D. Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
E. Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.
F. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
G. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
H. Section 23 23 00, REFRIGERANT PIPING.
I. Section 23 31 00, HVAC DUCTS AND CASINGS.

1.3 QUALITY ASSURANCE

A. Refer to specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

1.4 SUBMITTALS

A. Submit in accordance with specification Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Manufacturer's literature and data:

1. Sufficient information, including capacities, pressure drops, and piping connections clearly presented, shall be included to determine compliance with drawings and specifications for units noted below:
   a. Packaged unitary heat recovery ventilators.
   b. Mini-split systems.
2. Unit Dimensions required clearances, operating weights accessories and start-up instructions.
3. Electrical requirements, wiring diagrams, interlocking and control wiring showing factory installed and portions to be field installed.
4. Mounting and flashing of the roof curb to the roofing structure with coordinating requirements for the roof membrane system.

C. Certification: Submit proof of specified ARI Certification.

D. Performance Rating: Submit catalog selection data showing equipment ratings and compliance with required sensible-to-heat-ratio, energy efficiency ratio (EER), and coefficient of performance (COP).

E. Operating and Maintenance Manual: Submit three copies of Operating and Maintenance manual to COR three weeks prior to final inspection.

F. Completed System Readiness Checklists provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

1.5 APPLICABLE PUBLICATIONS

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

B. Air-Conditioning, Heating, and Refrigeration Institute (AHRI):

1. 210/240-2017 Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment
2. 270-2015 Sound Rating of Outdoor Unitary Equipment

3. 520-2004 Performance Rating of Positive Displacement Condensing Units

C. Air Movement and Control Association (AMCA):
1. 210-2016 Laboratory Methods of Testing Fans for Aerodynamic Performance Rating (ANSI)
2. 410-1996 Recommended Safety Practices for Users and Installers of Industrial and Commercial Fans

D. American National Standards Institute (ANSI):
1. S12.51-2017 Acoustics - Determination of Sound Power Levels of Noise Sources Using Sound Pressure - Precision Method for Reverberation Rooms (same as ISO 3741:1999)

E. American Society of Civil Engineers (ASCE)
1. ASCE 7-2017 Minimum Design Loads for Buildings and Other Structures

F. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):
1. Handbook 2016 HVAC Systems and Equipment
2. 15-2019 Safety Standard for Refrigeration Systems (ANSI)
3. 62.1-2016 Ventilation for Acceptable Indoor Air Quality (ANSI)

G. American Society of Testing and Materials (ASTM):
1. B117-2018 Standard Practice for Operating Salt Spray (Fog) Apparatus

H. Military Specifications (Mil. Specs.):
1. IMIL-PRF-26915D Primer Coating, for Steel Surfaces

I. American Society of Civil Engineers (ASCE):
1. ASCE 7-2010 Minimum Design Loads for Buildings and Other Structures

J. National Electrical Manufacturer's Association (NEMA):
1. ICS 1-2005 Industrial Controls and Systems: General Requirements
2. MG 1-2019 Motors and Generators (ANSI)

K. National Fire Protection Association (NFPA) Publications:
1. 90A-2018 Standard for the Installation of Air-Conditioning and Ventilating Systems

PART 2 - PRODUCTS

2.1 PACKAGED HEAT RECOVERY VENTILATORS

A. General:

1. The ERV unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, control circuit board and blowers with motors, filters, and insulated foam air guides. Each unit will have an automatic by-pass damper system for economic operation under certain conditions. The unit shall have factory installed control board with functions for local, remote, and optional control modes.
   a. Performance Certified to ARI Standard 1060.
2. Unit Cabinet:
   a. The cabinet shall be fabricated of galvanized steel, and covered with polyurethane foam insulation as necessary with steel mounting points securely attached.
3. Blowers:
   a. The unit shall be furnished with two (2) direct drive centrifugal blowers running simultaneously supplying and extracting air at the same rate for balanced ventilation air flow.
      1) The blower motors shall be a directly connected to the blower wheels and have permanently lubricated bearings.
4. The blowers and motors shall be mounted for quiet operation.
5. Heat Exchanger
   a. The heat exchanger element shall be constructed of specially treated cellulous fiber membrane separated by corrugated layers to allow total heat (sensible and latent) energy recovery from the exhaust air to the supply air or from the supply air to the exhaust air as determined by design conditions.
      1) The ERV unit shall have protective filters installed at both the supply and exhaust sides of the heat exchanger with an access cover to allow easy maintenance.
   b. Bypass Damper

1) The ERV shall have an automatic supply side by-pass damper to allow inbound ventilation air to by-pass the heat exchanger core when outside weather conditions warrant.
2) The mechanism for opening and closing the bypass damper shall be a 208V-230V synchronous electric motor through an actuator. The motor will drive a steel cable connected to an mechanical damper flap to allow fresh air to bypass the heat exchanger.
3) Supply and return air thermistor shall control the damper.

B. Filter
1. The ERV shall be equipped with factory installed air filters located at each intake face (both supply and exhaust sides) of the heat recovery core to clean the air and prevent clogging.

C. Mounting
1. Mounting of the ERV shall be as indicated in the plans and drawings. The ERV shall not require and condensate pan or receptacle nor condensate drain or piping. Mounting may be horizontal or vertical and the unit may be inverted as required by ductwork connection.
a. Electrical
1) The units will require a 208-230Volt, 1 Phase, 60Hz power supply.
b. Control
1) Independent control by contact closure from other sensor driven controllers, switch, or timers.
c. ERV operating sound level shall not exceed 37 dB(A) 59 in under center of unit at maximum fan speed.

D. Ductwork:
1. The installer shall supply, install, test and commission all interconnecting ductwork for the ERV units.
a. Ductwork sizing, layout, fittings, etc shall be in strict accordance with the design requirements.
b. The two outdoor ducts must be covered with heat insulating material in order to prevent condensation from forming.

c. The two outdoor ducts must be tilted at a gradient (1/30 or more) down toward the outdoor area from ERV unit.

E. Preheater (For Winter Design Temperature Less than 14\af3\f3\af3\af3\f3\'b0 F):

1. A suitable pre-heater shall be supplied and installed to pre-heat and maintain the air entering the ERV to above 14 F.
   a. The heater shall be sized to increase the temperature of the incoming supply air based on the heating (winter) design condition of the applicable site.
   b. The pre-heater shall be installed according to the manufacturer' s recommendation.

2.2 MINI-SPLIT SYSTEMS

A. General

1. The Heat Pump/Cooling Only system shall be a split system with Variable Speed Inverter Compressor technology. The system shall consist of a horizontal discharge, single phase outdoor unit and a matched capacity indoor unit.
2. Mini-split systems shall utilize R-454B refrigerant.
3. The outdoor unit shall provide electrical power for the connected indoor unit.
4. The units shall be tested by a Nationally Recognized Testing Laboratory (NRTL) and shall bear the ETL label.
5. The units shall be rated in accordance with Air-conditioning, Heating, and Refrigeration Institute' s (AHRI) Standard 210/240 and bear the ARI Certification label.
6. The units shall be manufactured in a facility registered to ISO 9001 and ISO 14001, which is a set of standards applying to environmental protection set by the International Standard Organization (ISO).

7. The units shall have a manufacturer' s parts and defects warranty for a period five (5) year from date of installation. The compressor shall have a warranty of seven (7) years from date of installation. If, during this period, any part should fail to function properly due to defects in workmanship or material, it shall be replaced or repaired at the discretion of the manufacturer. This warranty does not include labor.

B. Outdoor Units

1. General

a. The outdoor unit shall be equipped with an electronic control board that interfaces with the indoor unit to perform all necessary operation functions.

b. The outdoor unit shall be capable of cooling operation down to ambient temperature of 0°F for heat pump systems and -20°F (-29°C) for cooling only systems without additional low ambient controls (optional wind baffle shall be required).

c. The outdoor unit shall be able to operate with a maximum height difference of 100 feet (30 meters) between indoor and outdoor units.

d. The outdoor unit shall be completely factory assembled, piped, and wired. Each unit must be test run at the factory.

e. Provide all outdoor units with wind baffles for low ambient operation.

2. Cabinet

a. The casing shall be constructed from galvanized steel plate, finished with an electrostatically applied, thermally fused acrylic or polyester powder coating for corrosion protection and have a Munsell 3Y 7.8/1.1 finish.

b. Mounting feet shall be provided and shall be welded to the base of the cabinet and be of sufficient size to afford reliable equipment mount and stability.

c. Easy access shall be afforded to all serviceable parts by means of removable panel sections.

d. The fan grill shall be of ABS plastic.

e. Cabinet mounting and construction shall be sufficient to withstand 155 MPH wind speed conditions for use in Hurricane condition areas. Mounting, base support, and other installation to meet Hurricane Code Conditions shall be by others.

3. Fan
   a. Units smaller than 3 ton nominal capacity shall be furnished with a single DC fan motor. Units 3 tons or larger shall have two (2) DC fan motors.
   b. The fan blade(s) shall be of aerodynamic design for quiet operation, and the fan motor bearings shall be permanently lubricated.
   c. The outdoor unit shall have horizontal discharge airflow. The fan shall be mounted in front of the coil, pulling air across it from the rear and dispelling it through the front. The fan shall be provided with a raised guard to prevent external contact with moving parts.
4. Coil
   a. The L shaped condenser coil shall be of copper tubing with flat aluminum fins to reduce debris build up and allow maximum airflow. The coil shall be protected with an integral metal guard.
   b. Refrigerant flow from the condenser shall be controlled by means of an electronic linear expansion valve (LEV) metering device. The LEV shall be control by a microprocessor controlled step motor.
5. Compressor
   a. The compressor shall be a DC twin-rotor rotary compressor with Variable Speed Inverter Drive Technology.
   b. The compressor shall be driven by inverter circuit to control compressor speed. The compressor speed shall dynamically vary to match the room load for significantly increasing the efficiency of the system which shall result in significant energy savings.

c. To prevent liquid from accumulating in the compressor during the off cycle, a minimal amount of current shall be automatically, intermittently applied to the compressor motor windings to maintain sufficient heat to vaporize any refrigerant. No crankcase heater is to be used.
d. The outdoor unit shall have an accumulator and high pressure safety switch. The compressor shall be mounted to avoid the transmission of vibration.

6. Electrical
a. The electrical power of the unit shall be 208 volts or 230 volts, single phase, 60 hertz. The unit shall be capable of satisfactory operation within voltage limits of 198 volts to 253 volts.
b. Power for the indoor unit shall be supplied from the outdoor unit using three (3) fourteen gauge AWG conductors plus ground wire connecting the units.
c. The outdoor unit shall be controlled by the microprocessor located in the indoor unit.
d. The control signal between the indoor unit and the outdoor unit shall be pulse signal 24 volts DC.
e. The unit shall have Pulse Amplitude Modulation circuit to utilize 98% of input power supply.

C. Indoor Units
1. Wall Mounted
a. General
1) The wall-mounted indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function, and a test run switch. Indoor unit and refrigerant pipes shall be charged with dehydrated air before shipment from the factory.
b. Cabinet

1) All casings, regardless of model size, shall have the same white finish.
2) Multi directional drain and refrigerant piping offering four (4) directions for refrigerant piping and two (2) directions for draining are required.
3) There shall be a separate back plate which secures the unit firmly to the wall.

c. Fan
1) The indoor fan shall be statically and dynamically balanced to run on a single motor with permanently lubricated bearings.
2) A manual adjustable guide vane shall be provided with the ability to change the airflow from side to side (left to right).
3) A motorized air sweep louver shall provide an automatic change in airflow by directing the air up and down to provide uniform air distribution.

d. Filter:
1) Return air shall be filtered by means of an easily removable, washable filter.

e. Coil:
1) The indoor coil shall be of nonferrous construction with smooth plate fins on copper tubing. The tubing shall have inner grooves for high efficiency heat exchange. All tube joints shall be brazed with phos-copper or silver alloy.
2) The coils shall be pressure tested at the factory.

f. Electrical:
1) The electrical power of the unit shall be 208 volts or 230 volts, 1 phase, 60 hertz. The system shall be capable of satisfactory operation within voltage limits of 198 volts to 253 volts. The power to the indoor unit shall be supplied from the outdoor unit.
2) A three (3) conductor AWG-14 wire with ground shall provide power feed and bi-directional control transmission between the outdoor and indoor units.

2. General:
   a. The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, electronic modulating linear expansion device, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function, and a test run switch. The unit shall have an auto-swing function for the horizontal vane. Indoor unit and refrigerant pipes shall be charged with dehydrated air before shipment from the factory.
3. Unit Cabinet:
   a. The casing shall have a Munsell 6.4Y 8.9/0.4 white finish.
   b. The cabinet panel shall have provisions for a field installed filtered outside air intake.
4. Fan:
   a. The indoor unit fan shall be an assembly with two, three, or four Sirocco fan(s) direct driven by a single motor.
   b. The indoor fan shall be statically and dynamically balanced to run on a motor with permanently lubricated bearings.
   c. An integral, motorized, multi-position, horizontal air sweep flow louver shall provide for uniform air distribution, up and down from the upper air outlet. Five (5) positions plus Auto and Swing shall be provided, controlled from the remote controller.
   d. The indoor unit shall include an AUTO fan setting capable of maximizing energy efficiency by adjusting the fan speed based on the difference between controller set-point and space temperature. The indoor fan shall be capable of five (5) speed settings, Low, Med1, Med2, High and Auto.
5. Filter:
   a. Return air shall be filtered by means of an easily removable, washable filter.
6. Coil:

a. The indoor coil shall be of nonferrous construction with smooth plate fins on copper tubing. The tubing shall have inner grooves for high efficiency heat exchange. All tube joints shall be brazed with phos-copper or silver alloy.
b. The coils shall be pressure tested at the factory.

7. Electrical:
a. The unit electrical power shall be 208/230 volts, 1 phase, 60 hertz.
b. A three (3) conductor AWG-14 wire with ground shall provide power feed and bi-directional control transmission between the outdoor and indoor units.
c. The indoor unit shall not have any supplemental electrical heat elements.

D. Controls
1. Provide each mini-split unit with manufacturer's wired thermostat unit.

E. Condensate Pumps
1. Provide condensate pumps for each unit.
2. Condensate pumps may be installed within the indoor units where allowed by the indoor unit manufacturer. Condensate pumps shall be installed outside the unit (attached to the wall with a wall bracket) where mounting inside the unit is not possible.
3. Condensate pumps shall be powered from the same electrical power connection feeding the mini-split unit system.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Rooftop Unit Support: Install unit level on structural sleepers or curbs. Coordinate wall penetrations and flashing with wall construction. Secure rooftop units to structural support with anchor bolts.

B. Pad Mounted Unit Support: Install unit level on concrete pad with curbs, rails, or mounting legs. Secure units to structural support with anchor bolts.

C. Install wind and seismic restraints according to manufacturer's written instructions. Wind and seismically restrained vibration isolation roof-curb rails are specified in Section 23\~05\~41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.
D. Install units level and plumb maintaining manufacturer’s recommended clearances and tolerances.
E. Install vibration spring isolators under base of self-contained unit, with minimum static deflection of 25 mm (1 inch) unless otherwise indicated. Refer to Section 23\~05\~41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT
F. Install ground-mounting, compressor-condenser components on 100 mm (4-inch) thick, reinforced concrete base; 100 mm (4 inches) larger on each side than unit. Concrete, reinforcement, and formwork are specified in Section 03\~30\~00, CAST-IN-PLACE CONCRETE. Coordinate anchor installation with concrete base.
G. Install seismic restraints.
H. Install and connect pre-charged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.2 CONNECTIONS

A. Install condensate drain, minimum connection size, with trap and indirect connection to nearest roof drain or area drain.
B. Install piping adjacent to units to allow service and maintenance.
C. Connect supply ducts to units with flexible duct connectors specified in Section 23 31 00, HVAC DUCTS and CASINGS.
D. Ground equipment and install power wiring, switches, and controls for self-contained and split systems.
E. Connect refrigerant piping to coils with shutoff valves on the suction and liquid lines at the coil and a union or flange at each connection at the coil and condenser.
F. Install ducts to the units with flexible duct connections.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections: After installing units and after electrical circuitry has been energized, test units for compliance with requirements. Inspect for and remove shipping bolts, blocks, and tie-down straps. After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment. Remove and replace malfunctioning units and retest as specified above.

3.4 STARTUP AND TESTING

A. Manufacturer's field service technician shall provide warranty start-up supervision and assist in programming of unit(s) controls and ancillary panels supplied as part of the manufacturer's computer room air conditioning system.

B. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the COR and Commissioning Agent. Provide a minimum of seven days prior notice.

3.5 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.

B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

3.6 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer' s technical representative for four hours to instruct VA personnel in operation and maintenance of units.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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SECTION 23 81 23
COMPUTER-ROOM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies process cooling split systems air conditioning unit.

B. Definitions:

1. Energy Efficiency Ratio (EER): A ratio calculated by dividing the cooling capacity in Btu/h by the power input in watts at any given set of rating conditions, expressed in Watts (Btu/h) per watt.
2. Coefficient of Performance (COP): A ratio calculated by dividing the change in heating or cooling capacity (Btu/h) to the energy consumed by the system (kW), expressed in Btu/kWh.
3. Unitary (AHRI): Consists of one or more factory-made assemblies, which normally include an evaporator or cooling coil, a compressor and condenser combination, and may include a heating function.
4. CRAC Units: Computer Room Air Conditioning Units.

1.2 RELATED WORK

A. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

C. Section 22 05 23, GENERAL-DUTY VALVES FOR PLUMBING PIPING.

D. Section 22 11 00, FACILITY WATER DISTRIBUTION.

E. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

F. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT.

G. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.

H. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

I. Section 23\~09\~23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

J. Section 23 23 00, REFRIGERANT PIPING.

K. Section 23~31~00, HVAC DUCTS AND CASINGS.

1.3 QUALITY ASSURANCE

A. Refer to specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

1.4 SUBMITTALS

A. Submit in accordance with specification Section 01\~33\~23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Manufacturer’s Literature and Data rated capacities (at design indoor and outdoor conditions), EER/COP, operating characteristics, required specialties and accessories. Submit published catalog selection data showing equipment ratings and compliance with required sensible ratio.
   1. Indoor Air Conditioning Units
   2. Glycol Pump Packages
   3. Dry Coolers
   4. Air Cooled Condensing Units
   5. Water Cooled Condensing Units
   6. Accessories

C. Submit detailed equipment assemblies with dimensions, operating weights, required clearances.

D. Submit wiring diagrams for power, alarm and controls.

E. Certification: Submit, simultaneously with shop drawings, a proof of certification:

F. Completed System Readiness Checklists provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

1.5 WARRANTY

A. The unit shall be guaranteed against all mechanical defects in material, parts or workmanship and shall be repaired or replaced at the Contractor's expense within the period of one year from final acceptance. Contractor shall adhere to a four-hour service response time to troubles during the guarantee period.

B. Provide the following manufacturer's extended warranties for all CRAC systems:
   1. 1-Year labor warranty covering labor to replace components that fail during 1st year of standard parts-only warranty.
   2. 5-Year parts-only warranty for all components (other than compressors).
   3. 5-Year parts-only warranty for compressors.

1.6 APPLICABLE PUBLICATIONS

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

B. Federal Specifications (Fed Spec):
   1. TT-C-490D-1993 Cleaning Methods for Ferrous Surfaces and Pretreatments for Organic Coatings

C. Air-Conditioning, Heating and Refrigeration Institute (AHRI) Standards:
   1. 210/240-2020 Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment
   2. 340/360-2019 Performance Rating of Commercial and Industrial Unitary Air Conditioning and Heat Pump Equipment
   3. 410-2011 Forced-Circulation Air-Cooling and Air-Heating Coils
   4. 460-2005 Performance Rating of Remote Mechanical-Draft Air-Cooled Refrigerant Condensers
   5. 520-2004 Performance Rating of Positive Displacement Condensing Units
   6. DCPP Directory of Certified Product Performance

D. Air Movement and Control Association (AMCA):
   1. 210-2016 Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating (ANSI)
   2. 410-1996 Recommended Safety Practices for Users and Installers of Industrial and Commercial Fans

E. American Society of Heating, Refrigerating, and Air-Conditioning Engineers Inc. (ASHRAE):
   1. 15-2019 Safety Standard for Refrigeration Systems (ANSI)
   2. Handbook 2020 HVAC Systems and Equipment
   3. Handbook 2018 Refrigeration
   4. 52.1-1992 Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices used in General Ventilation for Removing Particulate Matter
   5. 62.1-2019 Ventilation for Acceptable Indoor Air Quality
   6. 90.1-2019 Energy Standard for Buildings except Low-Rise Residential Buildings

F. American Society of Testing and Materials (ASTM):
   1. B117-2018 Standard Practice for Operating Salt Spray (Fog) Apparatus
G. National Electrical Manufacturer's Association (NEMA):
   1. MG 1-2018 Motors and Generators (ANSI)
H. National Fire Protection Association (NFPA) Publications:
   1. 70-2020 National Electrical Code
   2. 90A-2021 Standard for the Installation of Air-Conditioning and Ventilating Systems

1.7 AS-BUILT DOCUMENTATION

A. Comply with requirements in Paragraph '' AS-BUILT DOCUMENTATION'' of Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

PART 2 - PRODUCTS

2.1 FLOOR-MOUNTED UNITS 28\~KW (8 TONS) AND LARGER

A. Frame
   1. The frame shall be welded, formed sheet metal. It shall be protected against corrosion using the autophoretic coating process. The frame shall be capable of being separated into three parts in the field to accommodate rigging through small spaces.
   2. Downflow Air-flow Configurations
      a. Downflow Air Supply
         1) The supply air shall exit from the bottom of the unit.
         2) Downflow Air, EC Fans Lowered into Floor Stand
            (a) The supply air shall exit from all sides of the floor stand.
            (b) Provide supply grilles at the front and sides of the floor stand or bottom of the unit.
         3) Downflow Air Return
            (a) The return air shall enter the unit from the top.
   3. Exterior Panels

a. The exterior panels shall be insulated with a minimum 1 in. (25 mm), 1.5 lb. (0.68 kg) density fiber insulation. The main front panel shall have captive quarter-turn fasteners. The main unit color shall be selected from the manufacturer's standard color options.

B. Filters
1. For Downflow units, the filter chamber shall be located within the cabinet, and filters shall be removable from the top of the unit. Filters shall be arranged in a flat bank configuration.
a. For Upflow units with front return, the filters shall be located within the cabinet and removed from the front of the unit. On Upflow units with rear return, the filters are removed from the side of the unit and are located in the rear-return filter box.
2. Filters
a. Filters, 2-in. MERV 8 Pre-Filter With 2-in. Filter MERV 8 or MERV 11.
3. Extra Filter Set
a. Extra set(s) of filters shall be provided per system.

C. Locking Disconnect Switch
1. The electrical panel shall provide at least 65,000A SCCR (60hz) or 5000A SCCR (50 Hz).
a. Short-circuit current rating (SCCR) is the maximum short-circuit current a component or assembly can safely withstand when protected by a specific overcurrent protective device(s) or for a specified time.

D. Short-Circuit Current Rating (SCCR)
1. The electrical panel shall provide at least 65,000A SCCR (60hz) or 5000A SCCR (50 Hz).
a. Short-circuit current rating (SCCR) is the maximum short-circuit current a component or assembly can safely withstand when protected by a specific overcurrent protective device(s) or for a specified time.

E. Fan Section
1. Electronically Commutated (EC) Fan

a. The fans shall be plug/plenum type, single inlet and shall be dynamically balanced. The drive package shall be direct drive, electronically commutated and variable speed. The fans shall be located to draw air over the coil to ensure even air distribution and maximum coil performance.
   1) EC fans shall be available on downflow (fans may be lowered into a raised floor with a minimum height of 24 in. (610 mm)) or upflow models. EC fans may operate within the unit cabinet, instead of under the floor.

2. Forward Curved Blower
   a. The fans shall be the centrifugal type, double-width and double-inlet, and shall be dynamically balanced as a completed assembly. The shaft shall be heavy-duty steel with self-aligning, permanently-sealed, pillow-block bearings with a minimum L3 life of 200,000 hours.
      1) The fans shall be located to draw air over the coil to ensure even air distribution and maximum coil performance.
      2) The fan motor shall be open drip-proof, premium efficiency, mounted to an automatic, spring tensioning base. The motor shall be removable from the front of the cabinet. The drive package shall be two-belt, variable speed, sized for 200% of the fan-motor horsepower.

F. Infrared Humidifier
   1. A humidifier shall be factory-installed inside the unit. The humidifier shall be of the infrared type, consisting of high-intensity quartz lamps mounted above and out of the water supply. The humidifier pan shall be stainless steel and arranged to be removable without disconnecting high-voltage electrical connections.
   2. The complete humidifier section shall be pre-piped, ready for field connection to the water supply.
   3. The humidifier shall be equipped with an automatic water-supply system and shall have an adjustable water-overfeed to prevent mineral precipitation.

4. A high-water detector shall shut-down the humidifier to prevent overflowing.
5. A 1 in. (24 mm) air-gap in compliance with ASME A112.1.2 section 2.4.2 (backsiphonage testing) shall prevent back-flow of the humidifier supply water.
6. The humidifier shall be removable from the front of the cabinet.

G. Three-Stage Reheat
1. The Thermal Management unit shall include a factory-installed reheat to control temperature during dehumidification.
2. The electric reheat coils shall be low watt density, 304/304 stainless steel fin tubular construction, protected by thermal safety switches, controlled in three stages. The reheat elements shall be removable from the front of the cabinet.

H. Refrigeration System
1. Evaporator Coil
a. The evaporator coil shall be A-frame design for downflow units and V-frame design for upflow units.
b. The coil shall be constructed of rifled copper tubes and aluminum fins.
c. A stainless-steel condensate drain pan shall be provided.
2. Compressorized Systems
a. Dual Refrigeration System
1) Each unit shall include two (2) independent refrigeration circuits and shall include hot gas mufflers (semi- hermetic compressor units only), liquid line filter driers, and refrigerant sight glasses with moisture indicator, externally equalized expansion valves, and liquid line solenoid valves. Compressors shall be located outside the air stream and shall be removable and serviceable from the front of the unit.
b. Scroll Compressors

1) The compressors shall be scroll-type. The compressors shall include a suction gas cooled motor, vibration isolators, thermal overloads, automatic reset high pressure switch with lockout after three failures, rotalock service valves, pump-down low-pressure transducer, suction-line strainer and a maximum operating speed of 3500 RPM.
2) Digital Scroll Compressors
(a) The compressor shall be scroll-type with a variable capacity operation capability. The compressor solenoid valve shall unload the compressor and allow for variable capacity operation. The compressor shall be suction gas cooled motor, vibration isolators, thermal overloads, automatic reset high-pressure switch with lockout after three failures, rotalock service valves, pump-down low-pressure transducer, suction-line strainer and a maximum operating speed of 3500 rpm.

c. Refrigerant-Side Economizer
1) Refrigerant system shall be configured to include refrigerant-side economizer functionality.
2) Refrigerant economizer module shall be outdoor-mounted, seperate from outdoor condensing unit, and shall be piped into the system refrigerant system.

3. Expansion Valve
a. Thermostatic Expansion Valve (TXV)
1) A manual adjustable externally equalized expansion valve thermostatic expansion valve (TXV) shall control the flow of liquid refrigerant entering the direct expansion coil. The TXV shall maintain consistent superheat of the refrigerant vapor at the outlet of the evaporator coil over the unit's operating range. The TXV shall prevent liquid refrigerant from returning to the compressor.

4. Crankcase Heaters
a. The compressors shall include crankcase heaters, powered from the indoor unit electric panel.

5. Refrigerant

a. The system shall be designed for use with R-407C refrigerant.

I. Cooling System

1. Air-Cooled System

a. System Description

1) The indoor evaporator refrigerant piping shall be filled with an inert gas holding charge and spun shut. Field relief of the Schrader valve shall indicate a leak-free system.

J. Controls

1. Microprocessor-Based Controller With Touchscreen

a. The controller shall be microprocessor-based with a 7-inch, high definition, capacitive, color touchscreen display and shall be mounted in an ergonomic, aesthetically pleasing housing. The display and housing shall be viewable while the front panel is open or closed. The controls shall be menu driven. The system shall display user menus for active alarms, event log, graphic data, unit view/status overview (including the monitoring of room conditions, operational status in percentage of each function, date and time), total run hours, various sensors, display setup and service contacts. A password shall be required to make system changes. Service menus shall include setpoints, standby settings (lead/lag), timers/sleep mode, alarm setup, sensor calibration, maintenance/wellness settings, options setup, system/network setup, auxiliary boards and diagnostics/service mode. The controller shall provide Ethernet/RS-485 ports dedicated for DDC connectivity.

1) Password Protection - The controller shall contain two unique passwords to protect against unauthorized changes. An auto hide/show feature shall allow the user to see applicable information based on the login used.

(a) Unit Backup/Restore - The user shall be able to create safe copies of important control parameters. The controller shall have the capacity for the user to automatically backup unit configuration settings to internal memory or USB storage drive. Configuration settings may be transferred to another unit for a more streamlined unit startup.

(b) Parameter Download - The controller shall enable the user to download a report that lists parameter names, factory default settings and user-programmed settings in .csv format for remote reference.

(c) Parameter Search - The controller shall have search fields for efficient navigation and parameter lookup.

(d) Parameter Directory - The controller shall provide a directory that lists all parameters in the control. The list shall provide Line ID numbers, parameter labels, and current parameter values.

(e) Context-Sensitive Help - The controller shall have an on-board help database. The database shall provide context-sensitive help to assist with setup and navigation of the menus.

(f) Display Setup - The user shall be able to configure the display information based on the specific user’s preference. Language, units of measure, screen contrast, home screen layout, back-light timer and the hide/show of certain readouts shall be configurable through the display.

(g) Additional Readouts - The display shall enable the user to configure custom widgets on the main screen. Widget options will include items such as fan speed, call for cooling, call for free-cooling, maintenance status, call for hot water reheat, call for electric reheat, call for dehumidification, call for humidification, airflow, static pressure, fluid flow rate and cooling capacity.

(h) Status LED' s - The controller shall show the unit' s operating status using an integral LED. The LED shall indicate if the unit has an active alarm; if the unit has an active alarm that has been acknowledged; or if the unit is On, Off or in standby status.

(i) Event Log - The controller shall automatically store the last 400 unit-only events (messages, warnings, and alarms).

(j) Service Contact Information - The controller shall be able to store the local service or sales contact information.

(k) Upgradeable - Controller firmware upgrades shall be performed through a USB connection.

(l) Timers/Sleep Mode – The menus shall allow various customer settings for turning the unit On or Off.

(m) Menu Layout - The menus shall be divided into two main menus: User and Service. The User screen shall contain the menus to access parameters required for basic unit control and setup. The Service screen shall be designed for service personnel and shall provide access to advanced control setup features and diagnostic information.

(n) Sensor Calibration - The menus shall allow unit sensors to be calibrated with external sensors.

(o) Maintenance/Wellness Settings - The menus shall allow reporting of potential component problems before they occur.

(p) Options Setup - The menus shall provide operation settings for the installed components.

(q) Auxiliary Boards - The menus shall allow setup of optional expansion boards.

(r) Various Sensors - The menus shall allow setup and display of optional custom sensors. The control shall include four customer-accessible analog inputs for sensors provided by others. The analog inputs shall accept a 4 to 20mA signal. The user shall be able to change the input to 0 to 5VDC or 0 to 10VDC. The gains for each analog input shall be programmable from the front display. The analog inputs shall be able to be monitored from the front display. When configuring the analog inputs, the selectable items to choose from shall include air pressure, fluid pressure, temperature, percentage, general amperage, condenser amps, compressor amps, reheat amps, humidifier amps, unit amps, fan amps factory standard, and not used.

(s) Diagnostics/Service Mode - The controller shall be provided with self-diagnostics to aid in troubleshooting. The microcontroller board shall be diagnosed and reported as pass/not pass. Control inputs shall be indicated as On or Off at the front display. Control outputs shall be able to be turned On or Off from the front display without using jumpers or a service terminal. Each control output shall be indicated by an LED on a circuit board.

(t) DDC Connectivity - The controller shall provide one Ethernet Port and RS-485 Port dedicated for DDC Connectivity. Provides ground fault isolated RS-485 Modbus, BACnet IP & Modbus IP network connectivity to Building Management Systems for unit monitoring and management. Also, provides ground fault isolated 10/100 baseT Ethernet connectivity for unit monitoring and management. The supported management interfaces include SNMP for Network Management Systems, HTTP for web page viewing, SMTP for email, and SMS for mobile messaging. The unit controller controller can support dual IP on one network and one 485 protocol simultaneously.

2. Alarms
    a. All unit alarms shall be annunciated through both audio and visual cues, clearly displayed on the screen, automatically recorded in the event log and communicated to the customers Building Management System/Building Automation System. The controller shall activate an audible and visual alarm in event of any of the following conditions:
        1) High Temperature
            (a) Low Temperature
            (b) High Humidity
            (c) Low Humidity
            (d) EC Fan Fault
            (e) Change Filters
            (f) Loss of Air Flow
            (g) Loss of Power
            (h) Compressor Overload
            (i) Humidifier Problem
            (j) High Head Pressure
            (k) Low Suction Pressure
            (l) Custom Alarms
    b. Custom alarm inputs shall be provided to indicate facility-specific events. Custom alarms can be identified with programmable labels. Frequently used alarm inputs include:
        1) Leak Under Floor
        2) Smoke Detected
        3) Standby Unit On
        4) Each alarm (unit and custom) shall be separately enabled or disabled, selected to activate the common alarm and programmed for a time delay of 0 to 255 seconds.
3. Control Methods and Options

a. The controller shall be factory-set to allow precise monitoring and control of the condition of the air entering and leaving the unit. This control shall include predictive methods to control air flow and cooling capacity-based control sensors installed. Proportional and Tunable PID shall also be user-selectable options.
b. Controlling Sensor Options
    1) Controller shall be flexible in the sense that it shall allow for controlling the capacity and fan from multiple different sensor selections. The sensor selections shall be:
    2) Cooling Capacity
        (a) Supply
        (b) Remote
        (c) Return
    3) Fan Speed
        (a) Supply
        (b) Remote
        (c) Return
        (d) Manual (for diagnostic or to receive a signal from the BMS through the Liebert remote monitoring devices or analog input)
        (e) Static Pressure
c. Temperature Compensation
    1) The controller shall be able to adjust the capacity output based on supply and return temperature conditions to meet SLA guidelines while operating to highest efficiency.
d. Humidity Control
    1) Dew point and relative humidity control methods shall be available (based on user preference) for humidity control within the conditioned space.

4. Multi-Unit Coordination

a. Controller shall save energy by preventing multiple units in an area from operating in opposing modes. Teamwork allows the control to optimize a group of connected cooling units equipped with same controller using the unit-to-unit network. There shall be three modes of teamwork operation:
   1) Teamwork Mode 1 (Parallel): Is best in small rooms with balanced heat loads. The controlling temperature and humidity sensor readings of all units in operation (fan On) are collected to be used for an average or worst-case sensor reading (user-selectable). The master unit shall send the operating requirements to all operating units in the group. The control band (temperature, fan and humidity) is divided and shared among the units in the group. Each unit will receive instructions on how to operate from the Master unit based on how far the system deviates from the setpoints. Evaporator fans and cooling capacity are ramped in parallel.
   2) Teamwork Mode 2 (Independent): The controller calculates the worse-case demand for heating, cooling humidification and dehumidification. Based on the greatest demand within the group, each unit operates independently, meaning that the unit may respond to the thermal load and humidity conditions based on the unit' s controlling sensors.
      (a) All sensor readings are shared.

3) Teamwork Mode 3 (Optimized Aisle): May be employed in large and small rooms with varying heat loads. Optimized Aisle is the most efficient teamwork mode that allows the unit to match cooling capacity with heat load. In the Optimized Aisle mode, the fans operate in parallel. Fans can be controlled exclusively by remote temperature or using static pressure with a secondary remote temperature sensor(s) as an override to ensure that the inlet rack temperature is being met. Cooling (Compressors or Economizer) is controlled through unit supply air conditions. The unit controller calculates the average or worst-case sensor reading (user-selectable) for heating, cooling humidification and dehumidification. Based on the demand within the group, units will be allowed to operate within that mode until room conditions are satisfied. This is the best form of control for a room with an unbalanced load.

5. Standby Lead-Lag Operation
   a. The controller shall allow scheduled rotation to keep equal run time on units and provide automated emergency rotation of operating and standby units.
6. Standby Unit Cascade

a. The controller shall have a cascade option to allow the units to turn On and Off based on heat load when utilizing Teamwork Mode 1, Independent mode or Teamwork Mode 3, Optimized Aisle mode with remote temperature sensors. In Teamwork Mode 1, Cascade mode will stage units On based on the temperature and humidity readings and their deviation from setpoint. In Teamwork 3 Mode, Cascade mode dynamically coordinates the fan speed to save energy and to meet the cooling demands. For instance, with a group of six units and only 50% of the heat load, the unit controller shall operate only four units at 80% fan speed and leave the other two units in standby. As the heat load increases, the controller shall automatically respond to the additional load and bring on another unit, increasing the units in operation to five. As the heat load shifts up or down, the control shall meet the needs by cascading units On or putting them into standby.

7. Wired Supply Sensor
   a. Each controller shall have one factory-supplied and connected supply air sensorFF that may be used as a controlling sensor or reference. When multiple sensors are applied for control purposes, the user shall be able to control based on a maximum or average temperature reading.
8. Virtual Master
   a. The controller shall allow for a virtual master that coordinates operation. The Virtual Master function shall provide smooth control operation if the group' s communication is compromised. When the lead unit, which is in charge of component staging in teamwork, unit staging and standby rotation, becomes disconnected from the network, the controller shall automatically assign a virtual master. The virtual master shall assume the same responsibilities as the master until communication is restored.
9. Virtual Backdraft Damper

a. The controller shall allow the use of a virtual back-draft damper, eliminating the need for a mechanical damper. This shall allow the fans to spin slower (15% or less) to act as a damper.

10. Compressor Short Cycle Control
    a. To help maximize the life of the compressor(s), there shall be start-to-next start delay for each single compressor. The control shall monitor the number of compressor starts in an hour. If the compressor starts more than 10 times in 60 minutes, the local display and remote monitoring shall notify the user through a Compressor 1 or 2 Short Cycle event.
11. Condenser Communication
    a. The controller shall communicate directly with the exterior condenser unit via field-supplied CANbus communication wires and via field-supplied, low-voltage interlock wires. This shall provide enhanced monitoring, alarming, diagnostics, low-noise mode, and condenser-fan reversal for cleaning mode.
12. System Auto Restart
    a. The auto restart feature shall automatically restart the system after a power failure. Time delay shall be programmable.
    b. A capacitive buffer shall be provided for continuous control operation through a power failure.
13. Sequential Load Activation
    a. On initial startup or restart after power failure, each operational load shall be sequenced with a minimum delay of one second to minimize total inrush current.
14. Low-Pressure Monitoring
    a. Units shall ship standard with low-pressure transducers for monitoring individual compressor suction pressure. If the pressure falls due to loss of charge or other mechanical cause, the corresponding circuit shall shut down to prevent equipment damage. The user shall be notified of the low-pressure condition through the local display and remote monitoring.
15. Winter Start Time Delay-Air-Cooled Operation

a. An adjustable software timer shall be provided to assist with compressor starting during cold weather. When the compressor starts, the low-pressure input shall be ignored for the period set in the user-adjustable timer. Once the time period has elapsed after the compressor start, the low-pressure input should remain in the normal state. If the low-pressure input does not remain in the normal state when the time delay has elapsed, the circuit shall lock out on low pressure. The low-pressure alarm shall be announced on the local display and communicated to remote monitoring systems.

16. Advanced Freeze Protection
    a. Units shall ship standard with advanced freeze protection enabled. The advanced freeze protection shall monitor the pressure of each circuit using a transducer. The control shall interact with the fan and compressor to prevent the unit coil from freezing if circuit suction pressure drops. Applying fan speed to direct expansion systems requires limitations to avoid freezing condensate on the coil when the unit operates below 100% fan speed. The controller's advanced freeze protection shall provide the ability to predict freeze conditions and correct this condition automatically by adjusting fan speed and compressor capacity. If a freeze condition is detected, the user shall be notified through the local display and remote monitoring systems.
17. Refrigerant Pressure Transducer Failure
    a. The control shall monitor the high-side and low-side refrigerant pressure transducers. If the control senses the transducer has failed, has been disconnected, has shorted or the reading has gone out of range, the user shall be notified through an event on the local display and remote monitoring. The corresponding circuit that the failure has occurred on shall be disabled to prevent unit damage.
18. Oil Return Protection

a. The control shall monitor compressor operation and staging to ensure that liquid and hot gas velocity are maintained for proper oil return to the compressor.

19. Digital Scroll High-Temperature Protection
    a. The control shall monitor digital scroll temperature during unit operation. A compressor temperature limit shall be imposed to help prevent damage to the compressor. If the temperature reaches the maximum temperature limit, the compressor shall be locked out for 30 minutes and an alarm shall be annunciated on the local display and through monitoring. After the initial lockout, the control shall continue to monitor compressor temperature during the off-cycle and re-enable the circuit once a safe operating temperature is reached and the 30 minutes has elapsed. The control shall store the number of high-temperature trips. The number of trips shall be accessible through the local display.
20. Digital Scroll Sensor Failure
    a. The control shall monitor the status of the digital scroll sensor(s). If the control senses that the thermistor is disconnected, shorted or the reading goes out of range, the user shall be notified through an event on the local display and remote monitoring.
21. Compressor Sequencing
    a. A user-selectable compressor sequencing parameter shall be provided and shall be accessible through the local display. This sequencing parameter shall present the user with three choices:
        1) Always use Compressor 1 as the lead compressor.
        2) Always use Compressor 2 as the lead compressor.
        3) Auto: The unit shall automatically stage compressors to keep each unit’s run time within 8 hours of the other’s run time. NOTE: The Auto setting attempts to maintain equal run times between compressors. However, the control will not turn Off a compressor to equalize run time when it is needed to control the space.

4) First priority: If the safety timings are acceptable for only one compressor, then it is the next to be started/stopped.
5) Second priority: If both compressors are Off: The compressor with fewer working hours is the next to start.
6) Third priority: If both compressors are in operation: the compressor that has been operating longer since the last start is the next to be stopped.

22. Compressor High- And Low-Temperature Limit Protection
    a. The control shall monitor the return air to ensure that the compressor(s) are operated within the manufacturer' s defined window of operation. If the return air temperature deviates from the manufacturer' s window of operation, the controller shall automatically adjust to prevent damage to the cooling unit or reduction in its reliability.
23. Compressor Run Time Monitoring
    a. The control shall log these compressor statistics:
        1) Number of compressor starts
        2) Run hours
        3) Average run time
        4) Starts per day
        5) Starts per day worst
        6) Number of high-pressure alarms
        7) Operating phase in which the high-pressure alarm occurred
        8) Number of low-pressure alarms
        9) Operating phase in which the low-pressure alarm occurred
        10) Number of compressor overloads
        11) Number of high-temperature alarms (scroll compressors)
        12) The user shall have the ability to monitor compressor operating temperature and pressure from the local display to be used as a diagnostic tool.
24. Manual Compressor Disablement

a. The user shall have the ability to disable compressor operation using a set of either normally open or normally closed dry contacts tied directly to the control or through remote monitoring. An additional enable/disable feature shall be provided to allow the user to permanently disable an individual compressor circuit for maintenance using the local display.

25. Manual Compressor Operation
    a. The user shall be able to operate each compressor(s) manually from the local display. The user shall be able to energize refrigeration components including liquid line solenoid valves, compressor contactors, electronic expansion valves and adjust capacity for troubleshooting or repair. The control shall monitor the compressor during manual operation and shall shut the compressor down if needed to prevent electrical or mechanical damage.
26. Flood Start Protection
    a. The control shall isolate each compressor through a dedicated circuit liquid line solenoid valve and/or electronic expansion valve. These devices, combined with a spring-closed discharge check valve and compressor crankcase heater (air-cooled models), shall help ensure refrigerant does not migrate/carry oil out of the compressor case during the off cycle.
27. Compressor Dehumidification
    a. The control shall permit the user to specify which compressor is used for dehumidification. The choices shall be: 1st compressor, 2nd compressor, 1 or 2, or BOTH.
        1) 1st compressor.
        2) 2nd compressor.
        3) 1st or 2nd compressor.
        4) Both compressors.

K. Factory Options (Indoor Units)
1. General: Provide the units with the following factory options.
2. High Temperature Sensor

a. The high-temperature sensor shall immediately shut down the environmental control system when activated. The high-temperature sensor shall be mounted in the electrical panel with the sensing element in the return air.

3. Smoke Sensor
   a. The smoke sensor shall immediately shut-down the environmental control system and activate the alarm system when activated. The smoke sensor shall be mounted in the electrical panel with the sensing element in the return-air compartment. The smoke sensor is not intended to function as or replace any room smoke- detection system that may be required by local or national codes. The smoke sensor shall include a supervision contact closure.
4. Condensate Pump, Dual Float
   a. The condensate pump shall be complete with integral dual-float switches, pump-and-motor assembly and reservoir. The secondary float shall send a signal to the local alarm and shall shut down the unit upon high water condition.
5. Low-Voltage Terminal Package
   a. Factory-installed and factory-wired terminals shall be provided.
      1) Remote Shutdown Terminals - Two additional pairs of terminals provide the customer with additional locations to remotely shut down the unit by field-installed devices or controls.
      2) Extra Common Alarm Contacts - Two additional pairs of terminals provide the customer with normally open contacts for remote indication of unit alarms.
      3) Main Fan Auxiliary Switch - One set of normally open contacts wired to the EC fan motor contactor will close when EC fan operation is required. This set of dry contacts could also be used to initiate air economizer operation. Air economizer and associated devices by others.
6. Main Fan Overload

a. A pair of normally open contacts shall be factory-installed and wired to indicate Main Fan Overload.

7. Compressor Overload
   a. A pair of normally open contacts shall be factory-installed and factory-wired to each compressor to indicate Compressor Overload.
8. Wired Remote Sensor(s)
   a. Each controller shall have up to ten 2T sensors (20 sensor readings total) for control or reference. As part of the unit-to-unit network, those sensors shall be shared and used to control the units and provide greater flexibility, visibility, and control using that to respond to changes in the data center. When the sensors are used for control, the user may set the control to be based off a maximum or average of a select highest temperature reading.
9. Floor Stand
   a. The floor stand shall be constructed of a welded steel frame. The floor stand shall have adjustable legs with vibration isolation pads.
   b. The floor stand shall be seismic rated and shall be bolted to the unit frame.
10. Return Air Plenum For Downflow Units
   a. The air plenum shall be constructed of 20-gauge steel, powder-coated to match unit color. The plenum shall be 24 in. (mm) high. A door shall be included in the front of the plenum to enable front filter access. Air shall enter the plenum from the top.

L. Exterior Condensing Units
   1. Air-Cooled Condenser
      a. General
         1) The condenser shall be designed to reject waste heat to outdoor air and to control refrigerant head pressure as indoor equipment loading and outdoor ambient conditions change.

2) The manufacturer shall design and furnish all equipment in the quantities and configurations shown on the project drawings.
3) Standard 60-Hz units shall be CSA-certified to the harmonized U.S. and Canadian product safety standard CSA C22.2 No 236/UL 1995 for '' Heating and Cooling Equipment'' and shall be marked with the CSA C-US logo.

b. Configuration
1) The air-cooled condenser shall be a factory-assembled unit, complete with integral electrical panel, designed for outdoor installation. The condenser shall be a draw-through design.
2) Condenser shall consist of microchannel condenser coil(s), propeller fan(s) direct-driven by individual fan motor(s), electrical controls, housing and mounting legs. The air-cooled condenser shall provide positive refrigerant head pressure control to the indoor cooling unit by adjusting heat rejection capacity.
3) The condenser shall be configured for use as part of a refrigerant-side economizer system.

c. Coils

1) Coils shall be constructed of aluminum microchannel tubes, fins and manifolds. Tubes shall be flat and contain multiple, parallel-flow microchannels and span between aluminum headers. Full-depth louvered aluminum fins shall fill spaces between the tubes. Tubes, fins and aluminum headers shall be oven-brazed to form a complete refrigerant-to-air heat exchanger coil. Copper stub pipes shall be electric resistance-welded to aluminum coils and joints protected with polyolefin to seal joints from corrosive environmental elements. Coil assemblies shall be factory leak tested at a minimum of 300 psig (2068 kPag). Hot-gas and liquid lines shall be copper and shall be brazed using nitrogen gas flow to the stub pipes with spun-closed ends for customer piping connections. Complete coil/piping assembly shall be then filled and sealed with an inert gas holding charge for shipment.

d. Fan Motor/Blade Assembly

1) The fan motor/blade assembly shall have an external rotor motor, fan blades and fan/finger guard. Fan blades shall be constructed of cast aluminum or glass-reinforced polymeric material. Fan guards shall be heavy gauge, close-meshed steel wire, coated with a black, corrosion-resistant finish. Fan terminal blocks shall be in an IP54 enclosure on the top of the fan motor. Fan assemblies shall be factory-balanced, tested before shipment, and mounted securely to the condenser structure.

2) EC Fan Motor

(a) The EC-fan motors shall be electronically commutated for variable-speed operation and shall have ball bearings. The EC fans shall provide internal overload protection through built-in electronics. Each EC-fan motor shall have a built-in controller and communication module linked via RS485 communication wire to each fan and the Premium Control Board, allowing each fan to receive and respond to precise fan speed inputs from the Premium Control Board.

e. Condenser Electrical Controls

1) Electrical controls and service-connection terminals shall be provided and factory-wired inside the attached control panel section. Only high-voltage supply wiring and low-voltage indoor-unit communication/interlock wiring are required at condenser installation.

2) EC Fan Speed and Premium Control

(a) The EC fan/Premium Control System shall include an electronic control board, EC-fan motor(s) with internal overload protection, refrigerant and ambient temperature thermistors and refrigerant pressure transducers. The Premium Control Board shall communicate directly with the indoor unit's controller via field- supplied CANbus communication wires and via field-supplied low-voltage interlock wires. The control board shall use sensor and communication inputs to maintain refrigerant pressure by controlling each EC fan on the same refrigerant circuit to the same speed. The Premium control board shall be rated to a temperature of - 30 F to 125 F (- 34.4 C to 51.7 C). The premium control shall be factory-set for fan speed control.

3) Locking Disconnect Switch

(a) A locking-type disconnect switch shall be factory-mounted and wired to the electrical panel and be capable of disrupting the flow of power to the unit and controlled via an externally mounted locking and lockable door handle. The locking disconnect shall be lockable in support of lockout/tagout safety programs.

4) Short Circuit Current Rating

(a) The electrical panel shall provide at least 65,000A SCCR.

f. Cabinet

1) The condenser cabinet shall be constructed of bright aluminum sheet and divided into individual fan sections by full-width baffles. Internal structural support members, including coil support frame, shall be galvanized steel for strength and corrosion resistance. Panel doors shall be provided on two sides of each coil/fan section to permit coil cleaning. An electrical panel shall be contained inside a factory-mounted NEMA 3R weatherproof electrical enclosure.

g. Mounting Legs

1) Galvanized-Steel Legs With Bracing: Condensers shall be shipped with 48 in. 1219 mm mounting legs with stabilization bracing. Legs, bracing and hardware shall be galvanized steel.

h. Fusible Plug Kit

1) A fusible plug kit shall be field-installed on the liquid line for compliance with building codes requiring refrigerant relief during high-temperature and building-fire conditions.

i. IBC/OSHPD Seismic Certification and IBC Wind/Snow Load Compliant Certification

1) IBC/OSHPD Seismic Certification and IBC Wind/Snow Load Compliant condensers shall be provided with any applicable bracing and field-installation instructions. Condensers shall bear a label certifying compliance with IBC/OSHPD requirements.

2.2 FLOOR-MOUNTED UNITS (3-8 TONS)

A. System Description: Single refrigeration circuit shall include a liquid line filter drier, a refrigerant sight glass with moisture indicator, an expansion valve, pressure safety switches, and a liquid line solenoid valve. The indoor evaporator refrigerant piping shall be filled with a nitrogen holding charge and spun shut. Field relief of the Schrader valve shall indicate a leak-free system.

B. Airflow Configuration

1. Upflow Supply with Front Air Return: The supply air shall exit from the top of the cabinet. The return air shall be through the front factory installed grilles. The EC fan shall be factory mounted in the upper portion of the unit. The fan shall be located to pull air through the filters and cooling coil to ensure even air distribution and maximum coil performance.

C. Cabinet

1. The exterior panels shall be 20 gauge steel and powder-coated with RAL 7021 black color paint to protect against corrosion. The exterior panels shall be insulated with 1/2'' to 1" (12.7 to 25.4mm), 1-1/2 lb. (0.68 kg) insulation. Front and side panels shall have captive, quarter-turn fasteners. The cabinet shall be designed so that all components are serviceable and removable using the front and right sides of the unit.
2. Double-Skin Panels: The exterior panels shall be internally lined with 20 gauge galvanized steel, sandwiching the insulation between the panels for easy cleaning.

D. Filters

1. The filter shall be an integral part of the system and located within the cabinet. The filter shall be deep-pleated, 2 in. (51mm) thick with a MERV 11 rating efficiency based on ASHRAE 52.2-2007.
2. A filter clog switch shall be included.

3. Mesh type, cleanable filters shall be unacceptable.
4. Extra Filter Set
    a. One extra set of filters shall be provided per system.

E. Refrigerant: The system shall be designed for use with R-410A refrigerant.

F. Compressors
1. Digital Scroll Compressor:
    a. The compressor shall be an R-410A scroll-type with variable capacity operation from 20-100%. The compressor solenoid valve shall unload the digital scroll compressor to provide variable capacity operation.
    b. The compressor shall have a suction gas cooled motor, EPDM Rubber vibration isolators, internal thermal overloads, automatic reset high pressure switch with lockout after three failure occurrences, rota-lock service valves, low pressure transducer, and crankcase heater.
    c. The compressor shall be removable and serviceable from the front of the unit.
    d. The crankcase heater and a discharge check valve shall be provided for additional system protection from refrigerant migration during Off cycles.
2. Compressor Sound Jacket: The compressor sound jacket shall reduce the level of sound emitted from the digital scroll compressor. It shall consist of a 3/8 inch closed cell polymeric 4.5 - 8.5 lb/ft3 density jacket that encloses the compressor.

G. Thermostatic Expansion Valve (TXV)
1. An electronically-controlled expansion valve (EEV) shall precisely control the flow of liquid refrigerant entering the direct-expansion coil. The EEV shall be of stepper-motor type. The EEV shall maintain consistent superheat of the refrigerant vapor at the outlet of the evaporator coil over the unit's operating range. The valve shall be controlled by a separate electronic controller. Superheat shall be determined through the suction-pressure-temperature method.

H. Coils

1. Hydrophilic-Coated Evaporator Coil: The direct-expansion, tilted-slab cooling coil shall be constructed of copper tubes and hydrophilic-coated aluminum fins. One stainless steel condensate drain pan shall be provided.

I. Fans
1. The unit shall be equipped with one plug fan: integral direct driven fan with backward-curved blades and electronically commutated (EC) DC motor.
2. The fan speed shall be variable and automatically regulated by the unit controller through all modes of operation.
3. The fan shall have a dedicated motor, fault monitoring circuitry, and speed controller, which shall provide a level of redundancy.
4. The impeller shall be made of aluminum and dynamically balanced.
5. The EC fan shall be located within the unit.

J. Locking Disconnect Switch
1. A locking-type fused disconnect switch shall be mounted in the electrical panel and shall be capable of disrupting the flow of power to the unit. The locking type shall consist of a main unit switch operational from outside the unit.
2. The electric panel compartment shall be accessible only with the switch in the Off position.

K. Short-Circuit Current Rating (SCCR): The electrical panel shall provide at least 65,000A SCCR.

L. Electric Reheat
1. Unit shall be provided a low-watt density 304/304 stainless steel finned-tubular electric reheat coil.
2. The reheat section shall include UL/CSA recognized safety switches to protect the system from overheating. The electric reheat shall be controlled in two stages.
3. The reheat elements shall be accessible from the right side of the cabinet.

M. Infrared Humidifier
1. The humidifier shall be of the infrared type, consisting of high intensity quartz lamps mounted above and out of the water supply.

2. The evaporator pan shall be stainless steel and arranged to be serviceable without disconnecting water supply lines, drain lines, or electrical connections.
3. The complete humidifier section shall be pre-piped ready for final connection. The infrared humidification system shall use bypass air to prevent over humidification of the controlled space. The auto flush system shall automatically flush deposits from the humidifier pan. The system shall be field adjustable to change the cycle time to suit local water conditions. A minimum 1 in. (25.4 mm) air gap within the humidifier piping assembly, in compliance with ASME A112.1.2 section 2.4.2 (backsiphonage testing), shall prevent back flow of the humidifier supply water.

N. Condensate Pumps
1. The dual-float condensate pump shall be complete with integral primary and secondary float switches, pump, motor assembly and reservoir. The secondary float shall send a signal to the local alarm and shut down the unit upon high water condition.
2. The condensate pump shall be factory-installed on upflow unitsfactory-installed on upflow units and field-installed on downflow units.

O. Controls
1. Unit Controller
a. The unit controller shall be microprocessor-based with a 7-inch, high definition, capacitive, color touchscreen display and shall be mounted in an ergonomic housing.
b. The display and housing shall be viewable while the front panel is open or closed.

c. The controls shall be menu-driven. The system shall display user menus for active alarms, event log, graphic data, unit view/status overview (including the monitoring of room conditions, operational status in percentage of each function, date and time), total run hours, various sensors, display setup and service contacts. A password shall be required to make system changes. Service menus shall include setpoints, standby settings (lead/lag), timers/sleep mode, alarm setup, sensor calibration, maintenance/wellness settings, options setup, system/network setup, auxiliary boards and diagnostics/service mode.
d. The unit controller shall provide Ethernet/RS-485 ports dedicated for DDC connectivity.
e. Password Protection: The unit controller shall contain two unique passwords to protect against unauthorized changes. An auto hide/show feature shall allow the user to see applicable information based on the login used.
f. Unit Backup and Restore: The user shall be able to create safe copies of important control parameters. The unit controller shall have the capacity for the user to automatically backup unit configuration settings to internal memory or USB storage drive. Configuration settings may be transferred to another unit for a more streamlined unit startup.
g. Parameter Download: The unit controller shall enable the user to download a report that lists parameter names, factory default settings and user programmed settings in.csv format for remote reference.
h. Parameter Search: The unit controller shall have search fields for efficient navigation and parameter lookup.
i. Context-Sensitive Help: The unit controller shall have an on-board help database. The database shall provide context-sensitive help to assist with setup and navigation of the menus.

j. Display Setup: The user shall be able to configure the display information based on the specific user's preference. Language, units of measure, screen contrast, home screen layout, back-light timer, and the hide/show of certain readouts shall be configurable through the display.
k. Additional Readouts: The display shall enable the user to configure custom widgets on the main screen. Widget options will include items such as fan speed, call for cooling, maintenance status, call for electric reheat, call for dehumidification, call for humidification, airflow, static pressure, and cooling capacity.
l. Status LEDs: The unit controller shall show the unit's operating status using an integral LED. The LED shall indicate if the unit has an active alarm; if the unit has an active alarm that has been acknowledged; or if the unit is On, Off or in standby status.
m. Event Log: The unit controller shall automatically store the last 400 unit-only events (messages, warnings, and alarms).
n. Service Contact Information: The unit controller shall be able to store the local service or sales contact information.
o. Upgradeable: Unit controller upgrades shall be performed through a USB connection.
p. Timers/Sleep Mode: The menus shall allow various customer settings for turning the unit On or Off.
q. Menu Layout: The menus shall be divided into two main menus: User and Service. The User screen shall contain the menus to access parameters required for basic unit control and setup. The Service screen shall be designed for service personnel and shall provide access to advanced control setup features and diagnostic information.
r. Sensor Calibration: The menus shall allow unit sensors to be calibrated with external sensors.
s. Maintenance/Wellness Settings: The menus shall allow reporting of potential component problems before they occur.

t. Options Setup: The menus shall provide operation settings for the installed components.

u. Auxiliary Boards: The menus shall allow setup of optional expansion boards.

v. Various Sensors: The menus shall allow setup and display of optional custom sensors. The control shall include four customer accessible analog inputs for field-supplied sensors. The analog inputs shall accept a 4 to 20mA signal. The user shall be able to change the input to 0 to 5VDC or 0 to 10VDC. The gains for each analog input shall be programmable from the front display. The analog inputs shall be able to be monitored from the front display.

w. Diagnostics/Service Mode: The unit controller shall be provided with self-diagnostics to aid in troubleshooting. The microcontroller board shall be diagnosed and reported as pass/not pass. Control inputs shall be indicated as On or Off at the front display. Control outputs shall be able to be turned On or Off from the front display without using jumpers or a service terminal. Each control output shall be indicated by an LED on a circuit board.

x. DDC Connectivity

1) The unit controller shall provide one Ethernet Port and RS-485 Port dedicated for DDC Connectivity, with ground fault isolated RS-485 Modbus, BACnet IP & Modbus IP network connectivity to Building Management Systems for unit monitoring and management. Also, the controller provides ground fault isolated 10/100 baseT Ethernet connectivity for unit monitoring and management.

2) The supported management interfaces include: SNMP for Network Management Systems, HTTP for web page viewing, SMTP for email, and SMS for mobile messaging. The iCOM controller shall support dual IP on one network and one 485 protocol simultaneously.

2. Alarms

a. All unit alarms shall be annunciated through both audio and visual cues, clearly displayed on the screen, automatically recorded in the event log and communicated to the customers Building Management System/Building Automation System. The unit controller shall activate an audible and visual alarm in event of any of the following conditions:
   1) High Temperature
   2) Low Temperature
   3) High Humidity
   4) Low Humidity
   5) EC Fan Fault
   6) Change Filters
   7) Loss of Air Flow
   8) Loss of Power
   9) Compressor Overload
   10) Humidifier Problem
   11) High Head Pressure
   12) Low Suction Pressure
   13) Custom Alarms

b. Custom alarm inputs shall be provided to indicate facility-specific events. Custom alarms can be identified with programmable labels. Provide the following custom alarm inputs:
   1) Standby Unit On

c. Each alarm (unit and custom) shall be separately enabled or disabled, selected to activate the common alarm and programmed for a time delay of 0 to 255 seconds.

3. Unit Controller Operation: The unit controller shall be factory-set to allow precise monitoring and control of the condition of the air entering and leaving the unit. This control shall include predictive methods to control air flow and cooling capacity based control sensors installed. Proportional and Tunable PID shall also be user selectable options.
4. Controlling Sensor Options

a. The unit controller shall be flexible in the sense that it shall allow for controlling the capacity and fan from multiple different sensor selections. The sensor selections shall be:
   1) Cooling Capacity
      (a) Supply
      (b) Remote
      (c) Return
   2) Fan Speed
      (a) Supply
      (b) Remote
      (c) Return
      (d) Manual (for diagnostic or to receive a signal from the BMS through the Liebert remote monitoring devices or analog input)
      (e) Static Pressure

5. Temperature Compensation: The unit controller shall be able to adjust the capacity output based on supply and return temperature conditions to meet SLA guidelines while operating at highest efficiency.
6. Humidity Control: Dew point and relative humidity control methods shall be available (based on user preference) for humidity control within the conditioned space.
7. Multi-Unit Coordination
   a. Unit controller teamwork shall save energy by preventing multiple units in an area from operating in opposing modes. Teamwork allows the control to optimize a group of connected cooling units equipped with identical controllers using the unit-to-unit network. There shall be three modes of teamwork operation:

1) Teamwork Mode 1 (Parallel): Is best in small rooms with balanced heat loads. The controlling temperature and humidity sensor readings of all units in operation (fan On) are collected to be used for an average or worst case sensor reading (user selectable). The master unit shall send the operating requirements to all operating units in the group. The control band (temperature, fan and humidity) is divided and shared among the units in the group. Each unit will receive instructions on how to operate from the Master unit based on how far the system deviates from the setpoints. Evaporator fans and cooling capacity are ramped in parallel.
2) Teamwork Mode 2 (Independent): The unit controller calculates the worse-case demand for heating, cooling humidification and dehumidification. Based on the greatest demand within the group, each unit operates independently, meaning that the unit may respond to the thermal load and humidity conditions based on the unit's controlling sensors. All sensor readings are shared.

3) Teamwork Mode 3 (Optimized Aisle): May be employed in large and small rooms with varying heat loads. Optimized Aisle is the most efficient teamwork mode that allows the unit to match cooling capacity with heat load. In the Optimized Aisle mode, the fans operate in parallel. Fans can be controlled exclusively by remote temperature or using static pressure with a secondary remote temperature sensor(s) as an override to ensure that the inlet rack temperature is being met. Cooling (Compressors or Economizer) is controlled through unit supply air conditions. The unit controller calculates the average or worst-case sensor reading (user-selectable) for heating, cooling humidification and dehumidification. Based on the demand within the group, units will be allowed to operate within that mode until room conditions are satisfied. This is the best form of control for a room with an unbalanced load.

8. Standby Lead-Lag: The unit controller shall allow scheduled rotation to keep equal run time on units and provide automated emergency rotation of operating and standby units.

9. Standby Unit Cascading: The unit controller cascade option shall allow the units to turn On and Off based on heat load when utilizing Teamwork Mode 1, Independent mode or Teamwork Mode 3, Optimized Aisle mode with remote temperature sensors. In Teamwork Mode 1, Cascade mode will stage units On based on the temperature and humidity readings and their deviation from setpoint. In Teamwork 3 Mode, Cascade mode dynamically coordinates the fan speed to save energy and to meet the cooling demands. For instance, with a controller group of six units and only 50% of the heat load, the unit controller shall operate only four units at 80% fan speed and leave the other two units in standby. As the heat load increases, the unit controller shall automatically respond to the additional load and bring on another unit, increasing the units in operation to five. As the heat load shifts up or down, the control shall meet the needs by cascading units On or putting them into standby.
10. Wired Supply Sensor
    a. Each unit controller shall have one factory-supplied and connected supply air sensor that may be used as a controlling sensor or reference. When multiple sensors are applied for control purposes, the user shall be able to control based on a maximum or average temperature reading.
11. Virtual Master
    a. The unit controller shall allow for a virtual master that coordinates operation. The Virtual Master function shall provide smooth control operation if the group's communication is compromised. When the lead unit, which is in charge of component staging in teamwork, unit staging and standby rotation, becomes disconnected from the network, the unit controller shall automatically assign a virtual master. The virtual master shall assume the same responsibilities as the master until communication is restored.
12. Virtual Backdraft Damper

a. The unit controller shall allow the use of a virtual back-draft damper, eliminating the need for a mechanical damper. This shall allow the fans to spin slower (15% or less) to act as a damper.

13. Compressor Short Cycle Control
    a. To help maximize the life of the compressor, there shall be start-to-next start delay for each compressor. The control shall monitor the number of compressor starts in an hour. If the compressor starts more than 10 times in 60 minutes, the local display and remote monitoring shall notify the user through a Compressor Short Cycle event.
14. Condenser Unit Communication
    a. The unit controller shall communicate directly with the condenser via field-supplied CANbus communication wires and via field-supplied, low-voltage interlock wires. This shall provide enhanced monitoring, alarming, diagnostics, low-noise mode, and condenser-fan reversal for cleaning mode.
15. System Auto Restart
    a. The auto restart feature shall automatically restart the system after a power failure. Time delay shall be programmable. An optional capacitive buffer may be provided for continuous control operation through a power failure.
16. Sequential Load Activation
    a. On initial startup or restart after power failure, each operational load shall be sequenced with a minimum delay of one second to minimize total inrush current.
17. Low-Pressure Monitoring
    a. Units shall ship standard with low-pressure transducers for monitoring compressor suction pressure. If the pressure falls due to loss of charge or other mechanical cause, the corresponding circuit shall shut down to prevent equipment damage. The user shall be notified of the low-pressure condition through the local display and remote monitoring.
18. Winter Start Time Delay

a. An adjustable software timer shall be provided to assist with compressor starting during cold weather. When the compressor starts, the low-pressure input shall be ignored for the period set in the user-adjustable timer. Once the time period has elapsed after the compressor start, the low-pressure input should remain in the normal state. If the low-pressure input does not remain in the normal state when the time delay has elapsed, the circuit shall lock out on low pressure. The low-pressure alarm shall be announced on the local display and communicated to remote monitoring systems.

19. Advanced Freeze Protection
    a. Units shall ship standard with advanced freeze protection enabled. The advanced freeze protection shall monitor the pressure of each circuit using a transducer. The control shall interact with the fan and compressor to prevent the unit coil from freezing if circuit suction pressure drops. Applying fan speed to direct expansion systems requires limitations to avoid freezing condensate on the coil when the unit operates below 100% fan speed. The unit controller advanced freeze protection provides the ability to predict freeze conditions and correct this condition automatically by adjusting fan speed and compressor capacity. If a freeze condition is detected, the user shall be notified through the local display and remote monitoring systems.
20. Advanced High-Pressure Protection
    a. When the compressor is initially activated, the system shall be monitored for high pressure. When high pressure is detected, the control shall alter the compressor operation and the condenser fan speed to reduce the system discharge pressure, preventing circuit shut down. If the unit is unsuccessful in correcting the problem through this interaction, an alarm shall occur and the affected compressor shall be immediately locked off. The control shall re-enable the compressor when the pressure returns to a safe level. This feature is standard on units equipped with liquid line transducers and digital scroll.

21. Refrigerant Pressure Transducer Failure
    a. The control shall monitor the high-side and low-side refrigerant pressure transducers. If the control senses the transducer has failed, has been disconnected, has shorted or the reading has gone out of range, the user shall be notified through an event on the local display and remote monitoring. The corresponding circuit that the failure has occurred on shall be disabled to prevent unit damage.
22. Oil Return Protection
    a. The control shall monitor compressor operation and staging to ensure that liquid and hot gas velocity are maintained for proper oil return to the compressor.
23. Digital Scroll High-Temperature Protection
    a. The control shall monitor digital scroll temperature during unit operation. A compressor temperature limit shall be imposed to help prevent damage to the compressor. If the temperature reaches the maximum temperature limit, the compressor shall be locked out for 30 minutes and an alarm shall be annunciated on the local display and through monitoring. After the initial lockout, the control shall continue to monitor compressor temperature during the off-cycle and re-enable the circuit once a safe operating temperature is reached and the 30 minutes has elapsed. The control shall store the number of high-temperature trips. The number of trips shall be accessible through the local display.
24. Digital Scroll Sensor Failure
    a. The control shall monitor the status of the digital scroll sensor(s). If the control senses that the thermistor is disconnected, shorted or the reading goes out of range, the user shall be notified through an event on the local display and remote monitoring.
25. Compressor High- and Low-Temperature Limit Protection

a. The control shall monitor the return air to ensure that the compressor is operated within the manufacturer' s defined window of operation. If the return air temperature deviates from the manufacturer' s window of operation, the unit controller shall automatically adjust to prevent damage to the cooling unit or reduction in its reliability.

26. Compressor Run Time Monitoring
    a. The control shall log these compressor statistics:
        1) Number of compressor starts
        2) Run hours
        3) Average run time
        4) Starts per day
        5) Starts per day worst
        6) Number of high-pressure alarms
        7) Operating phase in which the high-pressure alarm occurred
        8) Number of low-pressure alarms
        9) Operating phase in which the low-pressure alarm occurred
        10) Number of compressor overloads
        11) Number of high-temperature alarms (scroll compressors)
    b. The user shall have the ability to monitor compressor operating temperature and pressure from the local display to be used as a diagnostic tool.
27. Flooded Start Protection
    a. The control shall isolate each compressor through a dedicated circuit liquid line solenoid valve and/or electronic expansion valve. These devices, combined with a spring-closed discharge check valve and compressor crank-case heater (air-cooled models), shall help ensure refrigerant does not migrate/carry oil out of the compressor case during the off cycle.

P. Factory Options (Indoor Units)
1. General: Provide the units with the following factory options.
2. High Temperature Sensor

a. This sensor shall be factory-installed in the unit and shall be factory-set to 125°F (52°C). It shall immediately shut down the environmental control system when activated. The sensor shall be mounted with the sensing element in the return air. This sensor is not meant to replace any fire detection system that may be required by local or national codes.

3. Smoke Sensor
   a. The smoke sensor samples the return air, shuts down the unit upon activation, and sends visual and audible alarms. Dry contacts are available for a remote customer alarm. The smoke sensor includes a "supervision" contact closure. This smoke sensor is not intended to function as or replace any room smoke detection system that may be required by local or national codes.
4. Remote Temperature & Humidity Sensor
   a. This sensor shall allow the control of the unit based on temperature/humidity conditions remote to the unit. This sensor shall be field-mounted and wired to the Liebert iCOM control board and the unit shall not have a return-air temperature/humidity sensor mounted inside the unit.
5. Low-Voltage Terminal Package
   a. Factory-installed and factory-wired terminals shall be provided for customer connection:
      1) Remote Shutdown Terminals - Two additional pairs of terminals provide the customer with additional locations to remotely shut down the unit by field-installed devices or controls.
      2) Extra Common Alarm Contacts - Two additional pairs of terminals provide the customer with normally open contacts for remote indication of unit alarms.
6. Compressor Overload Sensor
   a. A factory-installed sensor designed to detect high compressor currents and provide iCOM input to shut down the compressor as a compressor protection feature.
7. Supply Plenum

a. Plenum Construction

1) The exterior panels shall be 20 gauge steel and powder-coated with black color paint to protect against corrosion. The exterior panels are insulated with 1/2” to 1" (12.7 to 25.4mm), 1-1/2 lb. (0.68 kg) insulation. Front and side panels shall have captive, quarter-turn fasteners.

b. Air Flow Configuration

1) Three-way Grille

(a) The unit shall be supplied with a three-way air discharge plenum. The plenum shall be 18 in. (457mm) high.

Q. Exterior Heat Rejection Units

1. Air-Cooled Condenser

a. General

1) The condenser shall be designed to reject waste heat to outdoor air and to control refrigerant head pressure as indoor equipment loading and outdoor ambient conditions change.

2) The manufacturer shall design and furnish all equipment in the quantities and configurations shown on the project drawings.

3) Standard 60Hz units shall be CSA-certified to the harmonized U.S. and Canadian product safety standard “CSA C22.2 No 236/UL 1995 for Heating and Cooling Equipment” and shall be marked with the CSA c-us logo.

b. Configuration

1) The air-cooled condenser shall be a factory-assembled unit, complete with integral electrical panel, designed for outdoor installation. The condenser shall be a draw-through design.

2) Condenser shall consist of microchannel condenser coil(s), propeller fan(s) direct-driven by individual fan motor(s), electrical controls, housing, and mounting legs. The Liebert air-cooled condenser shall provide positive refrigerant head pressure control to the indoor cooling unit by adjusting heat rejection capacity.

c. Coils

1) Microchannel coils shall be constructed of aluminum microchannel tubes, fins, and manifolds. Tubes shall be flat and contain multiple, parallel flow microchannels and span between aluminum headers. Full-depth louvered aluminum fins shall fill spaces between the tubes. Tubes, fins, and aluminum headers shall be oven-brazed to form a complete refrigerant-to-air heat exchanger coil. Copper stub pipes shall be electric resistance welded to aluminum coils and joints protected with polyolefin to seal joints from corrosive environmental elements. Coil assemblies shall be factory leak tested at a minimum of 300 psig (2068kPag). Hot gas and liquid lines shall be copper and shall be brazed using nitrogen gas flow to the stub pipes with spun-closed ends for customer piping connections. Complete coil/piping assembly shall be then filled and sealed with an inert gas holding charge for shipment.

d. Fan Motor/Blade Assembly

1) The fan motor/blade assembly shall have an external rotor motor, fan blades and fan/finger guard. Fan blades shall be constructed of cast aluminum or glass-reinforced polymeric material. Fan guards shall be heavy gauge, close-mesh steel wire, coated with a black corrosion resistant finish. Fan terminal blocks shall be in an IP54 enclosure on the top of the fan motor. Fan assemblies shall be factory-balanced, tested before shipment and mounted securely to the condenser structure.

2) EC Fan Motor

(a) The EC fan motors shall be electronically commutated for variable speed operation and shall have ball bearings. The EC fans shall provide internal overload protection through built-in electronics. Each EC fan motor shall have a built-in controller and communication module, linked via RS485 communication wire to each fan and the Premium Control Board, allowing each fan to receive and respond to precise fan speed inputs from the Premium Control Board.

e. Condenser Electrical Controls

1) Electrical controls and service connection terminals shall be provided and factory-wired inside the attached control panel section. Only high-voltage supply wiring and low voltage indoor unit communication/interlock wiring are required at condenser installation.

2) EC Fan Speed and Premium Control

(a) The EC fan/Premium Control System shall include an electronic control board, EC fan motor(s) with internal overload protection, refrigerant and ambient temperature thermistors, and refrigerant pressure transducers. The Premium Control Board shall communicate directly with the indoor unit's Liebert iCOM control via field-supplied CANbus communication wires and via field-supplied low voltage interlock wires. The control board shall use sensor and communication inputs to maintain refrigerant pressure by controlling each EC fan on the same refrigerant circuit to the same speed. The Premium control board shall be rated to a temperature of -30˚F to 125˚F. The premium control shall be factory set for (fan speed) (fan speed with Liebert Lee-Temp™) (fan speed with unheated receivers for EEV) control.

3) Locking Disconnect Switch

(a) A Locking-Type disconnect switch shall be factory-mounted and wired to the electrical panel and be capable of disrupting the flow of power to the unit and controlled via an externally mounted locking and lockable door handle. The locking disconnect shall be lockable in support of lockout/tagout safety programs.

4) Short Circuit Current Rating: The electrical panel shall provide at least 65,000A SCCR.

f. Cabinet

1) The condenser cabinet shall be constructed of bright aluminum sheet and divided into individual fan sections by full width baffles. Internal structural support members, including coil support frame, shall be galvanized steel for strength and corrosion resistance. Panel doors shall be provided on two sides of each coil/fan section to permit coil cleaning.

2) An electrical panel shall be contained inside a factory-mounted NEMA 3R weatherproof electrical enclosure.

g. Mounting Legs

1) Condensers shall be shipped with 48 in. (1219mm) mounting legs with stabilization bracing. Legs, bracing, and hardware shall be galvanized steel.

h. Fusible Plug Kit

1) A fusible plug kit shall be field-installed on the liquid line for compliance with building codes requiring refrigerant relief during high temperature and building fire conditions.

i. IBC/OSHPD Seismic Certification and IBC Wind/Snow Load Compliant Unit

1) IBC/OSHPD Seismic Certification and IBC Wind/Snow Load Compliant condensers shall be provided with any applicable bracing and field-installation instructions. Condensers shall bear a label certifying compliance with IBC/OSHPD requirements.

2.3 SPECIAL TOOLS

A. If any part of equipment furnished under these specifications requires a special tool for assembly, adjustment, setting, or maintenance and the tool is not readily available from the commercial tool market, furnish the necessary tools with equipment as a standard accessory.

2.4 CRAC SYSTEM ACCESSORIES

A. Unit Controller Network Switch (with Touchscreen Interface)
   1. The network switch is designed for networking multiple unit-level controllers together.
   2. Provide with locking steel enclosure.
   3. Provide network switch enclosure with 9'' color touchscreen display.
   4. Each enclosure shall contain two 8-port network switches, providing a total of 13 Ethernet ports available for controller unit-to-unit networking.
   5. Provide with field supplied, hard wired, 16AWG, 100-240VAC universal (12V, 1.5A) single-phase input power supply for 120V or 230V operation with factory supplied power connector.

2.5 REFRIGERANTS

A. All refrigerants shall be EPA approved.
B. Refrigerant shall be as specified by manufacturer for use with each system.

2.6 OILS

A. Oils used in CRAC systems shall be as approved by manufacturer.
B. Oils shall be POE (polyolester) type.

\B PART 3 - EXECUTION

3.1 INSTALLATION

A. Handle and install refrigeration units and accessories in accordance with the instructions and recommendations of the manufacturer.
B. Coordinate installation of Computer room Air Conditioning Units with Computer room access flooring installer.
C. Field Refrigerant Piping: As specified in specification Section 23 23 00, REFRIGERANT PIPING.

D. Field Piping: Glycol Piping, Hot water Piping, as specified in specification Section 23\~21\~13, HYDRONIC PIPING.
E. Electrical System Connections and Equipment Ground: As specified in Division 26 Sections.

3.2 CONNECTIONS

A. Coordinate piping installations and specialty arrangements with schematics on Drawings and with requirements specified in piping systems. If Drawings are explicit enough, these requirements may be reduced or omitted.
B. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
C. Install piping adjacent to machine to allow service and maintenance.
D. Water and Drainage Connections:
    1. General: Comply with applicable requirements in Section 22 05 23, GENERAL-DUTY VALVES FOR PLUMBING PIPING, Section 22 11 00, FACILITY WATER DISTRIBUTION, and Section 22 13 00, FACILITY SANITARY AND VENT PIPING.
    2. Provide adequate connections for condensate drain and humidifier flushing system.
    3. Mesh screen filter elements located in humidifier supply solenoid valves should be removed from the CRAC units prior to startup.
    4. Provide line-size wye strainer with stainless steel mesh element and (2) line-size ball valves for isolation outside the CRAC unit.
E. Refrigerant Piping Connections:
    1. Comply with applicable requirements in Section 23\~23\~00, REFRIGERANT PIPING.
    2. Provide shutoff valves and piping.

3.3 UNIT CONTROLLER NETWORK SWITCH (WITH TOUCHSCREEN INTERFACE)

A. Contractor shall hire UL inspector to provide field UL certification of unit controller network switch assembly.
B. Provide Cat-6 network wiring between switch and all CRAC units in the same space.

1. Comply with requirements in Division(s) 26 and 27 for network wiring.

3.4 FIELD QUALITY CONTROL

A. Tests and Inspections:
   1. Inspect for and remove shipping bolts, blocks, and tie-down straps.
   2. After installing computer-room air conditioners and after electrical circuitry has been energized, test for compliance with requirements.
   3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. After startup service and performance test, change filters and flush humidifier.

3.5 STARTUP AND TESTING

A. Manufacturer's field service technician shall provide warranty start-up supervision and assist in programming of unit(s) controls and ancillary panels supplied as part of the manufacturer's computer room air conditioning system.

B. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the COR and Commissioning Agent. Provide a minimum of 7 days prior notice.

3.6 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.

B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

3.7 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer' s technical representative for 8 hours to instruct VA personnel in operation and maintenance of units.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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SECTION 23 81 45
VARIABLE REFRIGERANT FLOW SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Variable capacity, multi-zoned heat pump heat recovery air conditioning system capable of simultaneous heating & cooling between connected zones.

1.2 RELATED WORK

A. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.
B. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.
C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
D. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT.
E. Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.
F. Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC.
G. Section 23 07 11, HVAC AND BOILER PLANT INSULATION.
H. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
I. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
J. Section 23 23 00, REFRIGERANT PIPING.
K. Section 23 31 00, HVAC DUCTS AND CASINGS.

1.3 QUALITY ASSURANCE

A. The units shall be listed by Electrical Testing Laboratories (ETL) and bear the ETL label.
B. All wiring shall be in accordance with the National Electrical Code (N.E.C.).
C. The units shall be manufactured in a facility registered to ISO 9001 and ISO14001 which is a set of standards applying to environmental protection set by the International Standard Organization (ISO).

D. All units must meet or exceed the 2010 Federal minimum efficiency requirements and the ASHRAE 90.1 efficiency requirements for VRF systems. Efficiency shall be published in accordance with the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) Standard 1230.

E. All manufacturer technical and service manuals must be readily available for download by any local contractor should emergency service be required. Registering and sign-in requirements which may delay emergency service reference are not allowed.

F. The VRF system shall be installed by a contractor with extensive installation experience with the specific manufacturer's VRF system, and that has undergone manufacturer's installation and service training.

G. The manufacturer shall have a minimum of five years experience with the manufacture and support of VRF systems.

1.4 SUBMITTALS

A. Contractor qualifications.

B. Product data for all system components, including controls and accessories.

C. Shop drawings of the entire control system shall be submitted and shall consist of a complete list of equipment and materials, including manufacturers' catalog data sheets and installation instructions. Samples of written Controller Checkout Sheets and Performance Verification Procedures for applications similar in scope shall be included for approval.

D. Shop drawings shall also contain complete wiring and schematic diagrams, sequences of operation, control system bus layout and any other details required to demonstrate that the system has been coordinated and will properly function as a system. Terminal identification for all control wiring shall be shown on the shop drawings.

E. As-built documentation.

F. Operation and maintenance information.

G. Any deviations from these specifications or the work indicated on the drawings shall be clearly identified in the Submittals.

H. Manufacturer's startup reports.

1.5 WARRANTY

A. The VRF units shall be covered by the manufacturer’s limited warranty for a period of one (1) year parts and seven (7) year compressor to the original owner from date of installation.
   1. If, during this period, any part should fail to function properly due to defects in workmanship or material, it shall be replaced or repaired at the discretion of the manufacturer. This warranty shall not include labor.

B. Extended Warranty: The VRF units shall be covered by an extended manufacturer’s limited warranty for a period of ten (10) years to the original owner from date of installation. In addition the compressor shall have a manufacturer’s limited warranty for a period of ten (10) years to the original owner from date of installation. The following conditions must be met:
   1. The VRF system must be designed using the manufacturer's system design software, by a manufacturer certified VRF system designer.
   2. The VRF system shall be installed by a contractor who has completed the manufacturer's service and installation training course required for the manufacturer's extended warranty.
   3. The VRF system installation shall be verified with commissioning report materials submitted to and approved by the system manufacturer, including:
      a. Manufacturer's system design software file.
      b. A one-hour maintenance tool record with system information. Record shall be provided with system in Ordinary Control Mode (not initial).
      c. Complete record of outdoor and indoor unit dip switch settings.
      d. Complete record of outdoor unit functions settings.

1.6 AS-BUILT DOCUMENTATION

A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR PLUMBING for as-built documentation requirements.

PART 2 – PRODUCTS

2.1 VARIABLE REFRIGERANT FLOW (VRF) SYSTEMS, GENERAL

A. Basis of Design:
   1. The basis of design is 2-pipe VRF systems with Branch Circuit (BC) Controllers for each outdoor unit/system.
   2. Three-pipe VRF systems with Branch Selector(s) at each runout/zone shall be acceptable.
   3. Alternate manufacturers must be submitted and accepted as shown and any additional material, cost, and labor to install same including any additional lines or components shall be incurred by the contractor.

B. VRF system(s) shall consist of:
   1. Outdoor heat pump units.
   2. Indoor units.
   3. Branch Circuit (BC) Controllers (for 2-pipe systems).
   4. Branch Selectors (for 3-pipe systems).
   5. Refrigerant piping.
   6. Controls.
   7. Refrigerant

C. VRF systems shall be provided from the same manufacturer and shall be designed for installation together to create a complete, functional system.

2.2 REFRIGERANT

A. VRF systems shall be designed to use R-410a or R-454b refrigerant.

B. Outdoor units shall be provided with a factory charge of refrigerant.

C. Contractor shall provide balance of refrigerant required to fill completed VRF system including all units and piping.

D. Polyolester (POE) oil shall be required.
   1. Prior to bidding, manufacturers using alternate oil types shall submit material safety data sheets (MSDS) and comparison of hygroscopic properties for alternate oil with list of local suppliers stocking alternate oil for approval at least two weeks prior to bidding.

2.3 OUTDOOR UNITS

A. General:

1. The outdoor units shall be equipped with multiple circuit boards that interface to the manufacturer's controls system and shall perform all functions necessary for operation. Each outdoor unit module shall be completely factory assembled, piped and wired and run tested at the factory.
2. All units requiring factory supplied twinning kits shall be piped together in the field, without the need for equalizing line(s). The manufacturer's factory twinning kit shall be utilized.

B. Outdoor units shall have a sound rating no higher than 61 dB(A) individually or 64 dB(A) twinned. Units shall have a sound rating no higher than 51 dB(A) individually or 54 dB(A) twinned while in night mode operation. If an alternate manufacturer is selected, any additional material, cost, and labor to meet published sound levels shall be incurred by the contractor.

C. Both refrigerant lines from the outdoor unit to the BC (Branch Circuit) Controller (Single or Main) shall be insulated in accordance with the installation manual.

D. The outdoor units shall have the capability of installing the main refrigerant piping through the bottom of the unit.

E. There shall be no more than 3 branch circuit controllers connected to any one outdoor unit.

F. Outdoor unit shall be able to connect to up to 50 indoor units depending upon model.

G. The outdoor unit shall have an accumulator with refrigerant level sensors and controls.

H. The outdoor unit shall have a high pressure safety switch, over-current protection, crankcase heater and DC bus protection.

I. The outdoor unit shall have the ability to operate with a maximum height difference of 164 feet and have total refrigerant tubing length of 1804-3100 feet. The greatest length is not to exceed 541 feet between outdoor unit and the indoor units without the need for line size changes or traps.

J. The outdoor unit shall be capable of operating in heating mode down to -4°F ambient temperatures or cooling mode down to 23°F ambient temperatures, without additional low ambient controls. If an alternate manufacturer is selected, any additional material, cost, and labor to meet low ambient operating condition and performance shall be incurred by the contractor.

K. The outdoor unit shall have a high efficiency oil separator plus additional logic controls to ensure adequate oil volume in the compressor is maintained. Unit must defrost all circuits simultaneously in order to resume full heating more quickly. Partial defrost which may extend "no or reduced heating" periods shall not be allowed.

L. Unit Cabinet:
   1. The casing(s) shall be fabricated of galvanized steel, bonderized and finished. Units cabinets shall be able to withstand 960 hours per ASTM B117 criteria for seacoast protected models (-BS models)

M. Fan:
   1. Each outdoor unit module shall be furnished with one direct drive, variable speed propeller type fan. The fan shall be factory set for operation under 0 in. WG external static pressure, but capable of normal operation under a maximum of 0.24 in. WG external static pressure via dipswitch.
   2. All fan motors shall have inherent protection, have permanently lubricated bearings, and be completely variable speed.
   3. All fan motors shall be mounted for quiet operation.
   4. All fans shall be provided with a raised guard to prevent contact with moving parts.

N. The outdoor unit shall have vertical discharge airflow.

O. Coil:
   1. The outdoor Hexicoil™ heat exchanger shall be of zinc coated aluminum construction with turbulating flat tube construction.
   2. The coil fins shall have a factory applied corrosion resistant blue-fin finish.
   3. A stainless steel pipe connects the aluminum coil to copper piping.

4. The coil shall be protected with an integral metal guard.
5. Refrigerant flow from the outdoor unit shall be controlled by means of an inverter driven compressor.
6. The outdoor coil shall include 4 circuits with two position valves for each circuit, except for the last stage.

P. Compressor:
1. Each outdoor unit module shall be equipped with one inverter driven scroll hermetic compressor. Non inverter-driven compressors, which cause inrush current (demand charges) and require larger wire sizing, shall not be allowed.
2. A crankcase heater(s) shall be factory mounted on the compressor(s).
3. The outdoor unit compressor shall have an inverter to modulate capacity. The capacity shall be completely variable with a turndown of 15%-5% of rated capacity, depending upon unit size.
4. The compressor will be equipped with an internal thermal overload.
5. The compressor shall be mounted to avoid the transmission of vibration.
6. Field-installed oil equalization lines between modules are not allowed. Prior to bidding, manufacturers requiring equalization must submit oil line sizing calculations specific to each system and module placement for this project.

Q. Controls:
1. The outdoor unit shall have the capability of up to 8 levels of demand control for each refrigerant system

R. Electrical:
1. The outdoor unit electrical power shall be 460 volts, 3-phase, 60 hertz.
2. The outdoor unit shall be capable of satisfactory operation within voltage limits of 414-506 volts.
3. The outdoor unit shall be controlled by integral microprocessors.
4. The control circuit between the indoor units, BC Controller and the outdoor unit shall be 24VDC completed using a 2-conductor, twisted pair shielded cable to provide total integration of the system.

2.4 BRANCH CIRCUIT CONTROLLERS

A. General

1. The BC (Branch Circuit) Controllers shall include multiple branches to allow simultaneous heating and cooling by allowing either hot gas refrigerant to flow to indoor unit(s) for heating or subcooled liquid refrigerant to flow to indoor unit(s) for cooling. Refrigerant used for cooling must always be subcooled for optimal indoor unit LEV performance; alternate branch devices with no subcooling risk bubbles in liquid supplied to LEV and are not allowed.
2. The BC (Branch Circuit) Controllers shall be specifically used with VRF manufacturer's systems. These units shall be equipped with a circuit board that interfaces to the manufacturer's controls system and shall perform all functions necessary for operation. The unit shall have a galvanized steel finish. The BC Controller shall be completely factory assembled, piped and wired. Each unit shall be run tested at the factory. This unit shall be mounted indoors, with access and service clearance provided for each controller. The sum of connected capacity of all indoor air handlers shall range from 50% to 150% of rated capacity. The BC Controller shall be suitable for use in plenums in accordance with UL1995 ed 4.

B. BC Unit Cabinet:

1. The casing shall be fabricated of galvanized steel.
2. Each cabinet shall house a liquid-gas separator and multiple refrigeration control valves.
3. The unit shall house two tube-in-tube heat exchangers.

C. Refrigerant Branches

1. All BC Controller refrigerant pipe connections shall be brazed or flared.

D. Refrigerant valves:

1. The unit shall be furnished with multiple branch circuits which can individually accommodate up to 54,000 BTUH and up to three indoor units. Branches may be twinned to allow more than 54,000 BTUH.

2. Each branch shall have multiple two-position valves to control refrigerant flow.
3. Service shut-off valves shall be field-provided/installed for each branch to allow service to any indoor unit without field interruption to overall system operation.
4. Linear electronic expansion valves shall be used to control the variable refrigerant flow.

E. Integral Drain Pan:
1. An Integral resin drain pan and drain shall be provided.

F. Electrical:
1. The unit electrical power shall be 208/230 volts, 1 phase, 60 Hertz.
2. The unit shall be capable of satisfactory operation within voltage limits of 187-228 (208V/60Hz) or 207-253 (230/60Hz).
3. The BC Controller shall be controlled by integral microprocessors
4. The control circuit between the indoor units and outdoor units shall be 24VDC completed using a 2-conductor, twisted pair shielded cable to provide total integration of the system.

2.5 BRANCH SELECTORS (3-PIPE SYSTEMS)

A. General: The branch selector boxes shall be designed specifically for use with VRF heat recovery system components.
1. These selector boxes shall be factory assembled, wired, and piped.
2. These branch controllers shall be run tested at the factory.
3. These selector boxes shall be mounted indoors.
4. When simultaneously heating and cooling, the units in heating mode shall energize their subcooling solenoid valve.
5. The number of connectable indoor units shall be in accordance with manufacturer's published data.

B. Unit Cabinet:
1. These units shall have a galvanized steel plate casing.
2. Each cabinet shall house multiple refrigeration control valves and a liquid gas separator.
3. The cabinet shall contain a tube in tube heat exchanger.
4. The unit shall have sound absorption thermal insulation material made of flame and heat resistant foamed polyethylene.

5. Nominal sound pressure levels shall not exceed 43 dB(A).

C. Dimensions: Each unit shall be no larger than 8-3/16” x 15-5/16” x 12-7/8”.

D. Refrigerant Valves:

1. The unit shall be furnished with 5 electronic expansion valves to control the direction of refrigerant flow.
2. The refrigerant connections shall be of the braze type.
3. Each circuit shall have at least one branch selector box.
4. Multiple circuits may be connected to a branch selector box with the use of a specialized joint provided they are within the capacity range of the branch selector.

E. Condensate Removal: The unit shall not require provisions for condensate removal.

F. Electrical:

1. The unit electrical power shall be 208/230 volts, 1 phase, 60 hertz.
2. The unit shall be capable of operation within the limits of 187 volts to 253 volts.
3. The minimum circuit amps (MCA) shall be 0.1 and the maximum fuse amps (MFA) shall be 15.
4. The control voltage between the indoor and outdoor unit shall be 16VDC non-shielded 2 conductor cable.

2.6 INDOOR UNIT - 4-WAY CEILING-RECESSED CASSETTE WITH GRILLE

A. General:

1. The indoor unit shall be a four-way cassette style indoor unit that recesses into the ceiling with a ceiling grille. The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, electronic modulating linear expansion device, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function, an emergency operation function, a test run switch, and the ability to adjust airflow patterns for different ceiling heights. Indoor unit and refrigerant pipes shall be charged with dehydrated air before shipment from the factory.

B. Unit Cabinet:
   1. The cabinet shall be space-saving ceiling-recessed cassette.
   2. The cabinet panel shall have provisions for a field installed filtered outside air intake.
   3. Branch ducting shall be allowed from cabinet.
   4. Four-way grille shall be fixed to bottom of cabinet allowing two, three or four-way blow.
   5. The grille vane angles shall be individually adjustable from the wired remote controller to customize the airflow pattern for the conditioned space

C. Fan:
   1. The indoor fan shall be an assembly with a turbo fan direct driven by a single motor.
   2. The indoor fan shall be statically and dynamically balanced to run on a motor with permanently lubricated bearings.
   3. The indoor fan shall consist of five (5) speed settings, Low, Mid1, Mid2, High and Auto.
   4. The fan shall have a selectable Auto fan setting that will adjust the fan speed based on the difference between controller set-point and space temperature.
   5. The indoor unit shall have an adjustable air outlet system offering 4-way airflow, 3-way airflow, or 2-way airflow.
   6. The indoor unit shall have switches that can be set to provide optimum airflow based on ceiling height and number of outlets used.
   7. The indoor unit vanes shall have 5 fixed positions and a swing feature that shall be capable of automatically swinging the vanes up and down for uniform air distribution.

D. The vanes shall have an Auto-Wave selectable option in the heating mode that shall randomly cycle the vanes up and down to evenly heat the space. Filter:
   1. Return air shall be filtered by means of a long-life washable filter

E. Coil:

1. The indoor coil shall be of nonferrous construction with smooth plate fins on copper tubing.
2. The tubing shall have inner grooves for high efficiency heat exchange.
3. All tube joints shall be brazed with phos-copper or silver alloy.
4. The coils shall be pressure tested at the factory.
5. A condensate pan and drain shall be provided under the coil.
6. The unit shall be provided with an integral condensate lift mechanism that will be able to raise drain water 33 inches above the condensate pan.
7. Both refrigerant lines to the indoor units shall be insulated in accordance with the installation manual.

F. Electrical:

1. The unit electrical power shall be 208/230 volts, 1-phase, 60 hertz.
2. The system shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz) or 207-253 volts (230V/60Hz).

G. Controls:

1. This unit shall use controls provided by the VRF manufacturer to perform functions necessary to operate the system.
2. Indoor unit shall compensate for the higher temperature sensed by the return air sensor compared to the temperature at level of the occupant when in HEAT mode. Disabling of compensation shall be possible for individual units to accommodate instances when compensation is not required.
3. Control board shall include contacts for control of external heat source. External heat may be energized as second stage with 1.8°F - 9.0°F adjustable deadband from set point.
4. Indoor unit shall include no less than four (4) digital inputs capable of being used for customizable control strategies.
5. Indoor unit shall include no less than three (3) digital outputs capable of being used for customizable control strategies.

2.7 INDOOR UNIT - CEILING-CONCEALED DUCTED

A. General:

1. The indoor unit shall be a ceiling-concealed ducted indoor fan coil design that mounts above the ceiling with a 2-position, field adjustable return and a fixed horizontal discharge supply and shall have a modulating linear expansion device. The unit shall be used with the an outdoor unit and branch circuit controller(s) of the same VRF system manufacturer and compatible series. The unit shall support individual control using VRF manufacturer's controllers. The unit shall be suitable for use in plenums in accordance with UL1995 ed 4.

B. Indoor Unit.

1. The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, electronic modulating linear expansion device, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, and an auto restart function. Indoor unit and refrigerant pipes shall be charged with dehydrated air before shipment from the factory.

C. Unit Cabinet:

1. The unit shall be, ceiling-concealed, ducted.
2. The cabinet panel shall have provisions for a field installed filtered outside air intake.

D. Fan:

1. Indoor units shall feature external static pressure settings from 0.14 to 0.60 in. WG.
   a. Units with high static option shall be capable of static pressure settings of up to 0.80 in. WG.
2. The indoor unit fan shall be an assembly with one or two fan(s) direct driven by a single motor.
3. The indoor fan shall be statically and dynamically balanced and run on a motor with permanently lubricated bearings.
4. The indoor fan shall consist of three (3) speeds, High, Mid, and Low plus the Auto-Fan function
5. The indoor unit shall have a ducted air outlet system and ducted return air system.

E. Filter:

1. Optional return filter box (rear or bottom placement) with high-efficiency filter shall be available for all indoor units.

F. Coil:
1. The indoor coil shall be of nonferrous construction with smooth plate fins on copper tubing.
2. The tubing shall have inner grooves for high efficiency heat exchange.
3. All tube joints shall be brazed with phos-copper or silver alloy.
4. The coils shall be pressure tested at the factory.
5. A condensate pan and drain shall be provided under the coil.
6. The condensate shall be gravity drained from the fan coil.
7. Both refrigerant lines to the indoor units shall be insulated in accordance with the installation manual.

G. Electrical:
1. The unit electrical power shall be 208/230 volts, 1-phase, 60 hertz.
2. The system shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz) or 207-253 volts (230V/60Hz).

H. Controls:
1. This unit shall use controls provided by the VRF manufacturer to perform functions necessary to operate the system.
2. Indoor unit shall compensate for the higher temperature sensed by the return air sensor compared to the temperature at level of the occupant when in HEAT mode. Disabling of compensation shall be possible for individual units to accommodate instances when compensation is not required.
3. Control board shall include contacts for control of external heat source. External heat may be energized as second stage with 1.8°F - 9.0°F adjustable deadband from set point.
4. Indoor unit shall include no less than four (4) digital inputs capable of being used for customizable control strategies.
5. Indoor unit shall include no less than three (3) digital outputs capable of being used for customizable control strategies.

2.8 INDOOR UNIT - WALL MOUNTED

A. General: The unit shall be a wall-mounted indoor unit section and shall have a modulating linear expansion device. The unit shall be used with the VRF outdoor unit and BC Controller. The unit shall have individual control using manufacturer's DDC controllers.

B. Indoor Unit: The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, electronic modulating linear expansion device, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function, and a test run switch. Indoor unit and refrigerant pipes shall be charged with dehydrated air before shipment from the factory.

C. Unit Cabinet:
   1. The casing shall have a white finish.
   2. Multi directional drain and refrigerant piping offering four (4) directions for refrigerant piping and two (2) directions for draining shall be standard.
   3. There shall be a separate back plate which secures the unit firmly to the wall.

D. Fan:
   1. The indoor fan shall be an assembly with one or two line-flow fan(s) direct driven by a single motor.
   2. The indoor fan shall be statically and dynamically balanced to run on a motor with permanently lubricated bearings.
   3. A manual adjustable guide vane shall be provided with the ability to change the airflow from side to side (left to right).
   4. A motorized air sweep louver shall provide an automatic change in airflow by directing the air up and down to provide uniform air distribution.

E. Filter: Return air shall be filtered by means of an easily removable, washable filter.

F. Coil:
   1. The indoor coil shall be of nonferrous construction with smooth plate fins on copper tubing.

2. The tubing shall have inner grooves for high efficiency heat exchange.
3. All tube joints shall be brazed with phos-copper or silver alloy.
4. The coils shall be pressure tested at the factory.
5. A condensate pan and drain shall be provided under the coil.
6. Both refrigerant lines to the indoor units shall be insulated.

G. Electrical:
1. The unit electrical power shall be as indicated on the drawings.
2. The system shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz).

H. Controls: This unit shall use controls provided by the manufacturer to perform functions necessary to operate the system.

2.9 CONTROLS

A. General:
1. The VRF manufacturer's control network (MCN) shall be capable of supporting remote controllers, centralized controllers, an integrated web based interface, graphical user workstation, and system integration to Direct Digital Control systems via BACNet as shown.
2. Gateways for adapting MCN to Direct Digital Control systems shall be acceptable.
3. Full graphics capability is required at user workstations.

B. Electrical Characteristics
1. General:
a. The MCN shall operate at 30VDC. Controller power and communications shall be via a common non-polar communications bus.
2. Wiring:
a. Control wiring shall be installed in a daisy chain configuration from indoor unit to indoor unit, to the BC controller (main and subs, if applicable) and to the outdoor unit. Control wiring to remote controllers shall be run from the indoor unit terminal block to the controller associated with that unit.

b. Control wiring for the remote controller shall be from the remote controller to the first associated indoor unit MCN connection. The remote controller shall be assigned an MCN address.
c. Control wiring for the wired and wireless controllers shall be from the remote controller (receiver) to the first associated indoor unit then to the remaining associated indoor units in a daisy chain configuration.
d. Control wiring for centralized controllers shall be installed in a daisy chain configuration from outdoor unit to outdoor unit, to the system controllers (centralized controllers and/or integrated web based interface), to the power supply.
e. The centralized controller shall be capable of being networked with other centralized controllers for control.

3. Wiring type:
a. Wiring shall be 2-conductor (16 AWG), twisted, stranded, shielded wire.

C. Network wiring shall be CAT-6 or CAT-6a with RJ-45 connection.

D. Controls Network
1. General: The MCN consists of remote controllers, centralized controllers, and/or integrated web based interface communicating over a high-speed communication bus. The MCN shall support operation monitoring, scheduling, occupancy, error email distribution, personal web browsers, tenant billing, online maintenance support, and integration with Building Management Systems (BMS) using BACNet interface.
2. Remote Controllers - Backlit Wired Type

a. The remote controller shall be capable of controlling up to 16 indoor units (defined as 1 group). The remote controller shall be compact in size, approximately 3'' x 5'' and have limited user functionality. The remote controller supports temperature display selection of Fahrenheit or Celsius. The remote controller shall allow the user to change on/off, mode (cool, heat, auto, dry, setback, and fan), temperature setting, and fan speed setting and airflow direction. The remote controller shall be able to limit the set temperature range from the controller. The remote controller shall be capable of night setback control with upper and lower set temperature settings. The room temperature shall be sensed at either the remote controller or the Indoor Unit dependent on the indoor unit dipswitch setting. The remote controller shall display a four-digit error code in the event of system abnormality/error.
b. The wired remote controller shall only be used in same group with wireless remote controllers or with other wired remote controllers, with up to two remote controllers per group.
c. The remote controller shall require no addressing. The remote controller shall connect using two-wire, stranded, non-polar control wire to connection terminal on the indoor unit. The remote controller shall require cross-over wiring for grouping across indoor units.

3. Centralized Controllers - Web-Enabled

a. The centralized controller shall be capable of controlling a maximum of 50 indoor units across multiple VRF outdoor units. The centralized controller shall be approximately 8-1/2'' x10'' in size and shall be powered from the external power supply. The centralized controller shall support system configuration, daily/weekly scheduling, monitoring of operation status, night setback settings, free contact interlock configuration and malfunction monitoring. The centralized controller shall have five basic operation controls which can be applied to an individual indoor unit, a group of indoor units (up to 50 indoor units), or all indoor units (collective batch operation). This basic set of operation controls for the centralized controller shall include on/off, operation mode selection (cool, heat, auto, dry, setback, and fan), temperature setting, fan speed setting, and airflow direction setting. Since the unit provides centralized control it shall be able to enable or disable operation of local remote controllers. In terms of scheduling, the centralized controller shall allow the user to define both daily and weekly schedules with operations consisting of ON/OFF, mode selection, temperature setting, air flow (vane) direction, fan speed, and permit/prohibit of remote controllers.
b. All centralized controllers shall be equipped with one RJ-45 Ethernet port to support interconnection with a network PC via a closed/direct Local Area Network (LAN).The centralized controller shall be capable of performing initial settings via a PC using the centralized controller' s initial setting browser.
c. Standard software functions shall be available so that the building manager can securely log into each centralized controller via the PC' s web browser to support operation monitoring, scheduling, error email, interlocking and online maintenance diagnostics. Standard software functions shall not expire.

d. Optional software functions: Provide VRF system with the following optional software functions:
1) Personal web browser for PC and MAC platforms.

4. DDC Integration
a. Provide the VRF manufacturer's BACNet interface unit. Unit shall be compliant with BACnet\'ae Protocol (ANSI/ASHRAE 135-2004) and be Certified by the (BTL) BACnet\'ae Testing Laboratories. The BACnet\'ae interface shall support BACnet Broadcast Management (BBMD). The BACnet\'ae interface shall support a maximum of 50 indoor units. Operation and monitoring points include, but are not limited to, on/off, operation mode, fan speed, prohibit remote controller, filter sign reset, alarm state, error code, and error address.

5. Web-Based User Interfaces
a. Provide the functions indicated below, along with any required software licenses.
1) PC Monitoring: The system shall be capable of monitoring and operating all indoor units from a networked PC's web browser.
2) PC Scheduling: The system shall be capable of creating customized daily, weekly, and annual schedules from a network PC's web browser. Schedules shall be applied to a single indoor unit, a group of indoor units, or collectively (batch) to all indoor units controlled by any centralized controller.
3) Online Maintenance Diagnostics: The system shall be capable of performing maintenance diagnostics via a network PC and centralized controller using Maintenance Tool Software.

2.10 REFRIGERANT PIPING

A. Refer to Section 23 23 00, REFRIGERANT PIPING.

B. Refrigerant supply and return piping shall be insulated.
1. Refer to Section 23 07 11, HVAC AND BOILER PLANT INSULATION.

2.11 POWER SUPPLY

A. Provide all VRF unit(s) and components with VRF manufacturer's power supply.

B. Contractor shall coordinate with Division 26 contractor for provision of electrical power (outlets) in locations to power VRF system components.

PART 3 - EXECUTION

3.1 GENERAL

A. All installation shall be in accordance with the manufacturer's installation instructions, the International Mechanical Code (IMC), and all requirements of the Veteran's Administration [Authority Having Jurisdiction].

B. Provide all systems checkout in order to comply with Section 23 05 11, COMMON WORK RESULTS FOR HVAC, Section 23 08 00, COMMISSIONING FOR HVAC, and the International Energy Conservation Code.

C. Refrigerant line sizing and installation shall be per manufacturer's instructions. Comply with all requirements for materials and installation specified in ASHRAE 15 and ASHRAE 34.

1. Provide isolation valve for all refrigerant piping at each zone of branch circuit controllers, or each zone controller, so that the zone can be isolated for maintenance. Valves type and material shall be as recommended by the manufacturer.

D. Provide all installation for a complete system as shown, to include outdoor units, indoor units, controllers, controls, refrigerant piping, insulation and the like. Tie all monitoring and control together through a dedicated PC or identical control through the EMCS.

E. Provide clean filters for each indoor unit immediately prior to occupancy and one complete set of spares.

3.2 CONTROLS

A. This system will be integrated into the building Direct Digital Control System (DDC). Provide all information and assistance required to achieve this integration. Refer to Section 23 09 23, DIRECT DIGITAL CONTROL SYSTEM FOR HVAC. Systems integration will be through a BACNet interface.

3.3 STARTUP

A. General

1. The VRF Manufacturer shall oversee and assist the installing contractor with the start up and commissioning of VRF equipment as outlined below. This process will be completed in two phases. Phase one shall cover the Pre-Start-Up inspection process, Phase two will cover the Physical start-up & initial adjustment of equipment.
2. All VRF System Commissioning activities shall be completed by an employee of the VRF manufacturer whose primary job responsibilities are to provide start up and commissioning of their products. Manufacturers reps, sales staff or in-house support staffs are not permitted to complete this scope of work.
3. A factory certified representative may assist the VRF manufacturer’s personnel in the completion of certain elements of work contained within this specification. Activities completed by a Factory Certified Representative shall be supervised onsite by the VRF manufacturer. Certified representatives shall not be used in lieu of the manufacturer’s personnel.
4. The installing contractor shall have been certified by the manufacturer to install VRF systems, having attended a minimum 3-day VRF Service & Installation course at an approved training center. A copy of this certificate shall be presented as part of the VRF equipment submittal process
5. The installing contractor shall assist the VRF manufacturer in their completion of the system review and have available a technician with appropriate diagnostic tools, materials and equipment, as required, for the duration of the inspection process. The technician shall be fully licensed and insured to complete necessary duties as directed under the supervision of the VRF manufacturer.

6. Upon completion of the Equipment Start-Up process, the VRF manufacturer shall provide a formal report outlining the status of the system, in electronic format only. Contained within this report shall be copies of all field inspection reports, required action items and status, Manufacturers design software As-Built, equipment model & serial numbers.
7. Completion of the Equipment Start-Up process shall verify that the VRF system has been installed per the Engineer' s design intent and complies with the VRF manufacturers engineering and installation specifications related to their equipment.
8. Compliance with federal, state and local codes as well as other authorities having jurisdictions are not part of this process and are the responsibility of the installing contractor.

B. Pre Start-Up Inspection
1. Contractor shall employ the services of the VRF manufacturer to provide a comprehensive field review of the completed VRF system installation, prior to the physical start up and operation of equipment. Upon satisfaction that the system meets the VRF manufacturer’s installation requirements and specifications, the contractor shall be allowed to proceed with the physical start up and operation of equipment.
2. Prior to the pre-start-up inspection, all systems components shall be in a final state of readiness having been fully installed and awaiting inspection.
3. The installing contractor shall provide the VRF manufacturer a copy of the electronic design file used in the design and engineering process of the system being inspected. This electronic design file shall have been completed on software approved by the specified VRF manufacturer and shall have been updated to reflect as-built conditions.

4. The installing contractor shall have prepared the refrigeration piping systems per equipment installation and service manuals. All refrigerant piping systems, upon completion of assembly, shall have been pressurized to a minimum 600 PSI, using dry nitrogen, and held for an uninterrupted 24HR period, with acceptable change due to atmospheric conditions.
   a. A record of the pressure check process shall be recorded and tagged at the outdoor unit. The tag shall contain the following information: date & time of pressure check start, fill pressure, outdoor temperature at start & stop, date & time of pressure check completion, and the person's full name & company information completing the pressure check.
   b. The installing contractor shall engage the General Contractor as a witness of the pressure check process, confirming that all steps and procedures related to the pressure check where properly followed and that the system held the holding pressure of 600PSI for a period of 24hr hours, with acceptable change due to atmospheric conditions. Witness information, including full name, company name, title, phone number and signature shall be recorded on same pressure tag used by installing contractor.
5. Upon completion of the 600 PSI pressure check, the system shall be evacuated to a level of 500 microns, where it will be held for a period of 1HR with no deflection. The installing contractor shall utilize the triple evacuation method per the equipment install and service manuals.
   a. Evacuation start & stop dates, times, and persons involved shall be recorded and tagged at the outdoor equipment.
   b. Installing contractor shall digitally capture a photo of the micron gauge reading, at the conclusion of the 1hr holding period, for each system and provide a copy to the VRF manufacturer. Each photo shall contain a tag providing the outdoor units Serial number.

6. Upon the completion of the 500-micron hold, the calculated additional refrigerant charge can be added. The calculated refrigerant charge shall have been calculated using the VRF manufacturers design software.
   a. Total refrigerant charge of the system shall be recorded and displayed at the outdoor unit by permanent means.
7. A review of the equipment settings shall be completed, with recommendations provided to improve system performance, if applicable. Physical changes of system settings will be completed by the contractor. Electronic recording of final DIP switches shall be provided as part of the commissioning report.
8. A comprehensive review and visual inspection shall be completed for each piece of equipment following a detailed check list, specific to the equipment being reviewed. A copy of the inspection report shall be provided as part of the manufacturers close out documentation. Any deficiencies found during the inspection process shall be brought to the attention of the installing contractor for corrective action. Any system components that are not accessible for proper inspection shall be noted as such.
9. Indoor Equipment report shall contain
   a. Model & Serial Number
   b. Equipment location
   c. Equipment Tag/Identification number
   d. Network Address & Port Assignment
   e. Digital recording of equipment settings
   f. Mounting/support method
   g. Seismic restraints used
   h. Proper service clearance provided
   i. Wiring and connection points are correct
   j. High voltage reading(s) within acceptable range
   k. Low voltage reading(s) within acceptable range
   l. Type of Remote Controller used and its location
   m. Occupied space temperature sensing location
   n. Air temperature readings within acceptable range
   o. Condensate pump interlock method

p. Fan E.S.P. setting
q. Air Filter condition
r. Height differential setting in heat mode
s. Noise level acceptable
t. Refrigerant pipe connected and insulated properly
u. Condensate pipe connected and insulated properly
v. Condition of connected ductwork
w. Fresh air connected
x. Humidifier connected and checked
y. Review of air balance report complete
z. Other interlocked systems, i.e. baseboard heat, booster fan etc.

C. Physical Start-Up of Equipment
1. Upon proper equipment start up by the contractor, following the manufacturers guidelines and specifications, an employee of the VRF manufacturer shall complete a review of the system performance and complete the following tasks:
2. Check and confirm all communication addressing of system components.
3. Check and confirm each indoor unit, individually, is properly piped and wired by commanding the indoor unit on, in either heat or cool mode and verifying proper response.
a. This process shall be digitally recorded and included as part of the close out documentation.
4. Electronically record a minimum of one-hour of operational data per refrigeration system.
5. Electronically record selector switch positions on all indoor and outdoor equipment.
6. The VRF manufacturer shall retain the electronically recorded data, collected during the start-up and equipment commissioning process, at a designated location within the US for future reference.

D. Close-Out Information

1. The VRF manufacturer shall issue a System Performance report at the completion of all fieldwork. Contained within this report shall be an overview of the system performance, recommendations, field reports, all electronic data, and as-built design file.

3.4 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.

B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

3.5 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer' s technical representative for 16 hours to instruct each VA personnel responsible in the operation and maintenance of the system.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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SECTION 23 82 00
CONVECTION HEATING AND COOLING UNITS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies unit heaters and cabinet unit heaters.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.
B. Section 01 09 00, GENERAL COMMISSIONING REQUIREMENTS.
C. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
D. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.
E. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
F. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.
G. Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.
H. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
I. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
J. Section 23 21 13, HYDRONIC PIPING.
K. Section 23 31 00, HVAC DUCTS and CASINGS.

1.3 QUALITY ASSURANCE

A. Refer to Paragraph, QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC. Provide guarantee in accordance with FAR clause 52.246-21.

1.4 SUBMITTALS

A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
B. Manufacturer's Literature and Data:
   1. Unit heaters.
   2. Cabinet unit heaters.
C. Certificates:
   1. Compliance with Article, QUALITY ASSURANCE.
   2. Compliance with specified standards.

D. Operation and Maintenance Manuals: Submit in accordance with Article, INSTRUCTIONS, in Section 01 00 00, GENERAL REQUIREMENTS.

E. Completed System Readiness Checklists provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 23 08 00 COMMISSIONING OF HVAC SYSTEMS.

1.5 APPLICABLE PUBLICATIONS

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

B. American National Standards Institute / Air Conditioning, Heating and Refrigeration Institute (ANSI/AHRI):

1. 440-2019 Performance Rating of Room Fan Coils

C. National Fire Protection Association (NFPA):

1. 90A-2018 Standard for the Installation of Air Conditioning and Ventilating Systems
2. 70-2021 National Electrical Code

D. Underwriters Laboratories, Inc. (UL):

1. 181-2013 Standard for Factory-Made Air Ducts and Air Connectors
2. 1995-2015 Heating and Cooling Equipment

PART 2 - PRODUCTS

2.1 UNIT HEATERS

A. General: Horizontal or vertical discharge type for electric heating medium.

B. Casing: Steel sheet, phosphatized to resist rust and finished in baked enamel. Provide hanger supports.

C. Fan: Propeller type, direct driven by manufacturer's standard electric motor. Provide resilient mounting. Provide fan guard for horizontal discharge units.

D. Discharge Air Control:

1. Horizontal discharge: Horizontal, adjustable louvers.

E. Electric Units: UL listed, factory wired to terminal strips for field connection of power and control wiring.

1. Heating elements: Nickel chromium alloy resistance wire embedded in a magnesium oxide insulating refractory and sealed in corrosion resisting metallic sheath with fins. Three phase heaters shall have balanced phases.
2. Thermal cutout: Manual reset type, which disconnects elements, and motor in the event normal operating temperatures are exceeded.
3. Magnetic contactor: Factory installed with low voltage relay for remote pilot duty thermostat operation.

F. Controls
1. Provide field installed remote wall mounted line voltage electric space thermostats or unit mounted return air thermostats to control the unit fan.

2.2 CABINET UNIT HEATERS

A. General: Vertical or horizontal type for electric heating medium, as indicated.

B. Cabinet: Not less than 1.3 mm (l8 gage) steel with front panel for vertical units and hinged front panel for horizontal units. Finish on exposed cabinet shall be factory-baked enamel in manufacturer's standard color as selected by the Architect. Provide 76 mm (3-inch) high sub-base for vertical floor mounted units.

C. Fan: Centrifugal blower, direct driven by a single phase, two-speed, electric motor with inherent overload protection. Provide resilient motor/fan mount.

D. Filter: Manufacturer's standard, one-inch thick, throwaway type MERV 7 filters.

E. Electric Coil: Spiral sheath or finned-tube construction with Cal-rod resistance elements in aluminum tubes. Units shall be UL listed and factory wired with unit mounted heat switch, magnetic contactors, high temperature cutout safety control, and fan override thermostat.

F. Controls
1. Provide heaters with manual fan starter and three-position (low, high and off) fan speed switch.
2. Provide field installed remote wall mounted line voltage electric space thermostats or unit mounted return air thermostats to control the unit fan.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Work shall be installed as shown and according to the manufacturer’s diagrams and recommendations.

B. Handle and install units in accordance with manufacturer's written instructions.

C. Support units rigidly so they always remain stationary. Cross-bracing or other means of stiffening shall be provided as necessary. Method of support shall be such that distortion and malfunction of units cannot occur.

3.2 OPERATIONAL TEST

A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

3.3 STARTUP AND TESTING

A. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the COR and Commissioning Agent. Provide a minimum of 7 days prior notice.

3.4 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.

B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

3.5 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer' s technical representative for four hours to instruct VA personnel in operation and maintenance of units.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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SECTION 23 85 00
RADON MITIGATION SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Design and installation of a complete radon mitigation system for all portions of the MCR building.

B. Design, installation and testing shall be in accordance with ANSI/AARST CC-1000.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

C. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

D. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

E. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT.

F. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.

G. Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.

H. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

1.3 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Where conflicts occur these specifications and the VA standard will govern.

B. American National Standards Institute (ANSI)

1. CC-1000-2023 Soil Gas Control Systems in New Construction of Multifamily, School, Commercial, and Mixed-Use Buildings

1.4 QUALITY ASSURANCE

A. Refer to article, QUALITY ASSURANCE in specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

B. Designer Qualifications: The designer shall possess a valid State of Maine Radon Mitigation Contractor registration. The designer shall have been actively and successfully engaged in the design of radon mitigation systems for the past 5 years, with a minimum of 10 completed projects.

C. Installer Qualifications: The installer shall possess a valid State of Maine Radon Mitigation Contractor registration. The installer shall have been actively and successfully engaged in the installation of radon mitigation systems for the past 5 years.

D. Materials and Equipment: All materials, devices, and equipment shall be approved by the VA. All materials and equipment shall be free from defect. All materials and equipment shall be new unless specifically indicated otherwise on the contract drawings.

1.5 SUBMITTALS

A. Submittals, including general content requirements, format, media, & number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES and Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

B. Submit as one package in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES. Prepare detailed working drawings that are signed by a mitigation contractor registered with the State of Maine. As the Government review is for technical adequacy only, the installer remains responsible for correcting any conflicts with other trades and building construction that arise during installation. Partial submittals will not be accepted. Material submittals shall be approved prior to the purchase or delivery to the job site. Suitably bind submittals in notebooks or binders and provide an index referencing the appropriate specification section. In addition to the hard copies, provide submittal items in Paragraphs 1.4(A)1 through 1.4(A)5 electronically in pdf format on a compact disc or as directed by the COR. Submittals shall include, but not be limited to, the following:

1. Manufacturer’s Literature and Data
    a. Fans.
    b. Piping & fittings.

c. Controls.
d. Roof cap assemblies.
2. Shop Drawings
3. Calculations
4. Designer's Qualifications
a. Resume shall include with project list.
5. Installer Qualifications
6. Operation & Maintenance Information
7. Warranty Certifications
8. Test Results
9. Certifications
10. Manufacturer Startup Reports
11. As-Built Documentation
a. Comply with requirements in Paragraph “AS-BUILT DOCUMENTATION” of Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
12. Commissioning System Readiness Checklists
13. Training Plans
14. Training Instructor Qualifications

1.6 DELIVERY, STORAGE, & HANDLING

A. Comply with requirements in paragraph DELIVERY, STORAGE AND HANDLING of Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
B. Accept products on site in factory packaging.
C. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

PART 2 - PRODUCTS

2.1 FANS

A. Fans shall be inline type, specifically designed for radon mitigation system use.
B. Fan body shall be fully sealed construction using thermoplastic materials. Fan body shall be fused & sealed using a vibration welding or similar process resulting in a permanently sealed construction.
C. Fan shall be provided with all adaptor fittings necessary to attach to radon system duct.

2.2 DUCT AND FITTINGS

A. Exhaust Duct
   1. PVC pipe, ASTM D2665, F891, or F1488. Pipe wall thickness shall be Schedule 40 minimum.
   2. In exposed areas within the building, pipe wall thickness shall be Schedule 80 minimum.
   3. Joints shall be solvent weld type.
   4. Joints shall be prepared with ASTM F656 primer.
   5. Solvent cement shall comply with ASTM D2564.

B. Flexible Couplings
   1. Flexible couplings shall comply with ASTM D5926, C1173, or an equivalent.

C. Subsurface Collection Duct
   1. PVC perforated pipe, ASTM D2665, F891, or F1488. Pipe wall thickness shall be Schedule 40 minimum.
   2. Joints shall be solvent weld type.
   3. Joints shall be prepared with ASTM F656 primer.
   4. Solvent cement shall comply with ASTM D2564.
   5. Pipe perforations shall be minimum 1/2" diameter.

2.3 ROOF CAP ASSEMBLIES

A. Roof cap assembly shall be directly attached to PVC duct. Roof cap shall be designed to prevent rain intrusion while allowing free exit of gasses from system.

PART 3 - EXECUTION

3.1 GENERAL

A. Design and installation shall meet ANSI/AARST CC-1000 requirements.

B. All products shall be installed in accordance with all manufacturer requirements.

3.2 INSTALLATION

A. Exposed radon ductwork shall be insulated.

B. Horizontal exhaust vent piping shall have a slope not less than 1/8 inch per foot downward toward the soil.

C. Horizontal exhaust duct sections shall not exceed 15 feet in length.

D. Exhaust duct systems shall be sealed water- and air-tight.

E. Exhaust duct between fan discharge and termination outside the building shall not be located in or below conditioned or occupiable space in the building.

F. Flexible couplings shall be utilized for the following applications:
   1. Joining pipe sections of dissimilar materials that are incompatible with solvent welding.
   2. Where physical constraints inhibit the ability to join pipe sections by means of a solvent weld.
   3. At locations allowed by code to provide temporary access to areas requiring maintenance or inspection.
   4. Inline fan installations.

G. Fans
   1. Radon fans shall be installed in vertical orientation only.
   2. Fans shall not be mounted to exhaust duct that connects to soil gas unless they can be electrically energized within 3 days of mounting.
   3. Fans shall be installed outside the building envelope.

H. Where perforated pipe is placed in a layer of sand or small stone, filter fabric, mesh, or similar shall be utilized to maintain air flow to the openings while preventing ingress of sand or stones that could obstruct the duct.

3.3 STARTUP AND TESTING

A. System startup and testing shall be performed by factory-approved representatives.

3.4 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS and Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and as required by the System Readiness Checklist provided by the Commissioning Agent.

B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS and Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

3.5 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer's technical representative for 4 hours to instruct VA personnel in operation and maintenance of units.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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SECTION 26 05 11
REQUIREMENTS FOR ELECTRICAL INSTALLATIONS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section applies to all sections of Division 26.

B. Furnish and install electrical systems, materials, equipment, and accessories in accordance with the specifications and drawings. Capacities and ratings of motors, transformers, conductors and cable, switchboards, switchgear, panelboards, motor control centers, generators, automatic transfer switches, and other items and arrangements for the specified items are shown on the drawings.

C. Electrical service entrance equipment and arrangements for temporary and permanent connections to the electric utility company’s system shall conform to the electric utility company's requirements. Coordinate fuses, circuit breakers and relays with the electric utility company’s system, and obtain electric utility company approval for sizes and settings of these devices.

D. Conductor ampacities specified or shown on the drawings are based on copper conductors, with the conduit and raceways sized per NEC. Aluminum conductors are prohibited.

1.2 MINIMUM REQUIREMENTS

A. The latest International Building Code (IBC), Underwriters Laboratories, Inc. (UL), Institute of Electrical and Electronics Engineers (IEEE), and National Fire Protection Association (NFPA) codes and standards are the minimum requirements for materials and installation.

B. The drawings and specifications shall govern in those instances where requirements are greater than those stated in the above codes and standards.

1.3 TEST STANDARDS

A. All materials and equipment shall be listed, labeled, or certified by a Nationally Recognized Testing Laboratory (NRTL) to meet Underwriters Laboratories, Inc. (UL), standards where test standards have been established. Materials and equipment which are not covered by UL standards will be accepted, providing that materials and equipment are listed, labeled, certified or otherwise determined to meet the safety

requirements of a NRTL. Materials and equipment which no NRTL accepts, certifies, lists, labels, or determines to be safe, will be considered if inspected or tested in accordance with national industrial standards, such as ANSI, NEMA, and NETA. Evidence of compliance shall include certified test reports and definitive shop drawings.

B. Definitions:

1. Listed: Materials and equipment included in a list published by an organization that is acceptable to the Authority Having Jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production or listed materials and equipment or periodic evaluation of services, and whose listing states that the materials and equipment either meets appropriate designated standards or has been tested and found suitable for a specified purpose.
2. Labeled: Materials and equipment to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the Authority Having Jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled materials and equipment, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.
3. Certified: Materials and equipment which:
   a. Have been tested and found by a NRTL to meet nationally recognized standards or to be safe for use in a specified manner.
   b. Are periodically inspected by a NRTL.
   c. Bear a label, tag, or other record of certification.
4. Nationally Recognized Testing Laboratory: Testing laboratory which is recognized and approved by the Secretary of Labor in accordance with OSHA regulations.

1.4 QUALIFICATIONS (PRODUCTS AND SERVICES)

A. Manufacturer’s Qualifications: The manufacturer shall regularly and currently produce, as one of the manufacturer's principal products, the materials and equipment specified for this project, and shall have manufactured the materials and equipment for at least three years.

B. Product Qualification:

1. Manufacturer's materials and equipment shall have been in satisfactory operation, on three installations of similar size and type as this project, for at least three years.
2. The Government reserves the right to require the Contractor to submit a list of installations where the materials and equipment have been in operation before approval.

C. Service Qualifications: There shall be a permanent service organization maintained or trained by the manufacturer which will render satisfactory service to this installation within four hours of receipt of notification that service is needed. Submit name and address of service organizations.

1.5 APPLICABLE PUBLICATIONS

A. Applicable publications listed in all Sections of Division 26 shall be the latest issue, unless otherwise noted.

B. Products specified in all sections of Division 26 shall comply with the applicable publications listed in each section.

1.6 MANUFACTURED PRODUCTS

A. Materials and equipment furnished shall be of current production by manufacturers regularly engaged in the manufacture of such items, and for which replacement parts shall be available. Materials and equipment furnished shall be new, and shall have superior quality and freshness.

B. When more than one unit of the same class or type of materials and equipment is required, such units shall be the product of a single manufacturer.

C. Equipment Assemblies and Components:

1. Components of an assembled unit need not be products of the same manufacturer.
2. Manufacturers of equipment assemblies, which include components made by others, shall assume complete responsibility for the final assembled unit.
3. Components shall be compatible with each other and with the total assembly for the intended service.
4. Constituent parts which are similar shall be the product of a single manufacturer.

D. Factory wiring and terminals shall be identified on the equipment being furnished and on all wiring diagrams.

E. When Factory Tests are specified, Factory Tests shall be performed in the factory by the equipment manufacturer, and witnessed by the contractor. In addition, the following requirements shall be complied with:

1. The Government shall have the option of witnessing factory tests. The Contractor shall notify the Government through the -COR a minimum of thirty (30) days prior to the manufacturer's performing of the factory tests.
2. When factory tests are successful, contractor shall furnish four (4) copies of the equipment manufacturer's certified test reports to the COR fourteen (14) days prior to shipment of the equipment, and not more than ninety (90) days after completion of the factory tests.
3. When factory tests are not successful, factory tests shall be repeated in the factory by the equipment manufacturer, and witnessed by the Contractor. The Contractor shall be liable for all additional expenses for the Government to witness factory re-testing.

1.7 VARIATIONS FROM CONTRACT REQUIREMENTS

A. Where the Government or the Contractor requests variations from the contract requirements, the connecting work and related components shall include, but not be limited to additions or changes to branch circuits, circuit protective devices, conduits, wire, feeders, controls, panels and installation methods.

1.8 MATERIALS AND EQUIPMENT PROTECTION

A. Materials and equipment shall be protected during shipment and storage against physical damage, vermin, dirt, corrosive substances, fumes, moisture, cold and rain.

1. Store materials and equipment indoors in clean dry space with uniform temperature to prevent condensation.
2. During installation, equipment shall be protected against entry of foreign matter, and be vacuum-cleaned both inside and outside before testing and operating. Compressed air shall not be used to clean equipment. Remove loose packing and flammable materials from inside equipment.

3. Damaged equipment shall be repaired or replaced, as determined by the COR.
4. Painted surfaces shall be protected with factory installed removable heavy kraft paper, sheet vinyl or equal.
5. Damaged paint on equipment shall be refinished with the same quality of paint and workmanship as used by the manufacturer so repaired areas are not obvious.

1.9 WORK PERFORMANCE

A. All electrical work shall comply with requirements of the latest NFPA 70 (NEC), NFPA 70B, NFPA 70E, NFPA 99, NFPA 110, OSHA Part 1910 subpart J – General Environmental Controls, OSHA Part 1910 subpart K – Medical and First Aid, and OSHA Part 1910 subpart S – Electrical, in addition to other references required by contract.

B. Job site safety and worker safety is the responsibility of the Contractor.

C. Electrical work shall be accomplished with all affected circuits or equipment de-energized. However, energized electrical work may be performed only for the non-destructive and non-invasive diagnostic testing(s), or when scheduled outage poses an imminent hazard to patient care, safety, or physical security. In such case, all aspects of energized electrical work, such as the availability of appropriate/correct personal protective equipment (PPE) and the use of PPE, shall comply with the latest NFPA 70E, as well as the following requirements:
   1. Only Qualified Person(s) shall perform energized electrical work. Supervisor of Qualified Person(s) shall witness the work of its entirety to ensure compliance with safety requirements and approved work plan.
   2. At least two weeks before initiating any energized electrical work, the Contractor and the Qualified Person(s) who is designated to perform the work shall visually inspect, verify and confirm that the work area and electrical equipment can safely accommodate the work involved.
   3. At least two weeks before initiating any energized electrical work, the Contractor shall develop and submit a job specific work plan, and energized electrical work request to the COR, and Medical Center’s Chief Engineer or his/her designee. At the minimum, the

work plan must include relevant information such as proposed work schedule, area of work, description of work, name(s) of Supervisor and Qualified Person(s) performing the work, equipment to be used, procedures to be used on and near the live electrical equipment, barriers to be installed, safety equipment to be used, and exit pathways.

4. Energized electrical work shall begin only after the Contractor has obtained written approval of the work plan, and the energized electrical work request from the COR, and Medical Center's Chief Engineer or his/her designee. The Contractor shall make these approved documents present and available at the time and place of energized electrical work.
5. Energized electrical work shall begin only after the Contractor has invited and received acknowledgment from the COR, and Medical Center's Chief Engineer or his/her designee to witness the work.

D. For work that affects existing electrical systems, arrange, phase and perform work to assure minimal interference with normal functioning of the facility. Refer to Article OPERATIONS AND STORAGE AREAS under Section 01 00 00, GENERAL REQUIREMENTS.

E. New work shall be installed and connected to existing work neatly, safely and professionally. Disturbed or damaged work shall be replaced or repaired to its prior conditions, as required by Section 01 00 00, GENERAL REQUIREMENTS.

F. Coordinate location of equipment and conduit with other trades to minimize interference.

1.10 EQUIPMENT INSTALLATION AND REQUIREMENTS

A. Equipment location shall be as close as practical to locations shown on the drawings.

B. Working clearances shall not be less than specified in the NEC.

C. Inaccessible Equipment:

1. Where the Government determines that the Contractor has installed equipment not readily accessible for operation and maintenance, the equipment shall be removed and reinstalled as directed at no additional cost to the Government.
2. "Readily accessible" is defined as being capable of being reached quickly for operation, maintenance, or inspections without the use of ladders, or without climbing or crawling under or over obstacles

such as, but not limited to, motors, pumps, belt guards, transformers, piping, ductwork, conduit and raceways.

D. Electrical service entrance equipment and arrangements for temporary and permanent connections to the electric utility company's system shall conform to the electric utility company's requirements. Coordinate fuses, circuit breakers and relays with the electric utility company's system, and obtain electric utility company approval for sizes and settings of these devices.

1.11 EQUIPMENT IDENTIFICATION

A. In addition to the requirements of the NEC, install an identification sign which clearly indicates information required for use and maintenance of items such as switchboards and switchgear, panelboards, cabinets, motor controllers, fused and non-fused safety switches, generators, automatic transfer switches, separately enclosed circuit breakers, individual breakers and controllers in switchboards, switchgear and motor control assemblies, control devices and other significant equipment.

B. Identification signs for Normal Power System equipment shall be laminated black phenolic resin with a white core with engraved lettering. Identification signs for Essential Electrical System (EES) equipment, as defined in the NEC, shall be laminated red phenolic resin with a white core with engraved lettering. Lettering shall be a minimum of 12 mm (1/2 inch) high. Identification signs shall indicate equipment designation, rated bus amperage, voltage, number of phases, number of wires, and type of EES power branch as applicable. Secure nameplates with screws.

C. Install adhesive arc flash warning labels on all equipment as required by the latest NFPA 70E. Label shall show specific and correct information for specific equipment based on its arc flash calculations. Label shall show the followings:

1. Nominal system voltage.
2. Equipment/bus name, date prepared, and manufacturer name and address.
3. Arc flash boundary.
4. Available arc flash incident energy and the corresponding working distance.
5. Minimum arc rating of clothing.

6. Site-specific level of PPE.

1.12 SUBMITTALS

A. Submit to the COR in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. The Government's approval shall be obtained for all materials and equipment before delivery to the job site. Delivery, storage or installation of materials and equipment which has not had prior approval will not be permitted.

C. All submittals shall include six copies of adequate descriptive literature, catalog cuts, shop drawings, test reports, certifications, samples, and other data necessary for the Government to ascertain that the proposed materials and equipment comply with drawing and specification requirements. Catalog cuts submitted for approval shall be legible and clearly identify specific materials and equipment being submitted.

D. Submittals for individual systems and equipment assemblies which consist of more than one item or component shall be made for the system or assembly as a whole. Partial submittals will not be considered for approval.

1. Mark the submittals, "SUBMITTED UNDER SECTION_____".
2. Submittals shall be marked to show specification reference including the section and paragraph numbers.
3. Submit each section separately.

E. The submittals shall include the following:

1. Information that confirms compliance with contract requirements. Include the manufacturer's name, model or catalog numbers, catalog information, technical data sheets, shop drawings, manuals, pictures, nameplate data, and test reports as required.

2. Elementary and interconnection wiring diagrams for communication and signal systems, control systems, and equipment assemblies. All terminal points and wiring shall be identified on wiring diagrams.
3. Parts list which shall include information for replacement parts and ordering instructions, as recommended by the equipment manufacturer.

F. Maintenance and Operation Manuals:

1. Submit as required for systems and equipment specified in the technical sections. Furnish in hardcover binders or an approved equivalent.
2. Inscribe the following identification on the cover: the words "MAINTENANCE AND OPERATION MANUAL," the name and location of the system, material, equipment, building, name of Contractor, and contract name and number. Include in the manual the names, addresses, and telephone numbers of each subcontractor installing the system or equipment and the local representatives for the material or equipment.
3. Provide a table of contents and assemble the manual to conform to the table of contents, with tab sheets placed before instructions covering the subject. The instructions shall be legible and easily read, with large sheets of drawings folded in.
4. The manuals shall include:
   a. Internal and interconnecting wiring and control diagrams with data to explain detailed operation and control of the equipment.
   b. A control sequence describing start-up, operation, and shutdown.
   c. Description of the function of each principal item of equipment.
   d. Installation instructions.
   e. Safety precautions for operation and maintenance.
   f. Diagrams and illustrations.
   g. Periodic maintenance and testing procedures and frequencies, including replacement parts numbers.
   h. Performance data.
   i. Pictorial "exploded" parts list with part numbers. Emphasis shall be placed on the use of special tools and instruments. The list shall indicate sources of supply, recommended spare and replacement parts, and name of servicing organization.
   j. List of factory approved or qualified permanent servicing organizations for equipment repair and periodic testing and maintenance, including addresses and factory certification qualifications.

G. Approvals will be based on complete submission of shop drawings, manuals, test reports, certifications, and samples as applicable.

H. After approval and prior to installation, furnish the COR with one sample of each of the following:

1. A minimum 300 mm (12 inches) length of each type and size of wire and cable along with the tag from the coils or reels from which the sample was taken. The length of the sample shall be sufficient to show all markings provided by the manufacturer.
2. Each type of conduit coupling, bushing, and termination fitting.
3. Conduit hangers, clamps, and supports.
4. Duct sealing compound.
5. Each type of receptacle, toggle switch, lighting control sensor, outlet box, manual motor starter, device wall plate, engraved nameplate, wire and cable splicing and terminating material, and branch circuit single pole molded case circuit breaker.

1.13 SINGULAR NUMBER

A. Where any device or part of equipment is referred to in these specifications in the singular number (e.g., "the switch"), this reference shall be deemed to apply to as many such devices as are required to complete the installation as shown on the drawings.

Coordinate with the applicable sections of Division 01 and 02.

1.14 ACCEPTANCE CHECKS AND TESTS

A. The Contractor shall furnish the instruments, materials, and labor for tests.

B. Where systems are comprised of components specified in more than one section of Division 26, the Contractor shall coordinate the installation, testing, and adjustment of all components between various manufacturer’s representatives and technicians so that a complete, functional, and operational system is delivered to the Government.

C. When test results indicate any defects, the Contractor shall repair or replace the defective materials or equipment, and repeat the tests for the equipment. Repair, replacement, and re-testing shall be accomplished at no additional cost to the Government.

1.15 WARRANTY

A. All work performed and all equipment and material furnished under this Division shall be free from defects and shall remain so for a period of one year from the date of acceptance of the entire installation by the Contracting Officer for the Government.

1.16 INSTRUCTION

A. Instruction to designated Government personnel shall be provided for the particular equipment or system as required in each associated technical specification section.

B. Furnish the services of competent and factory-trained instructors to give full instruction in the adjustment, operation, and maintenance of the specified equipment and system, including pertinent safety requirements. Instructors shall be thoroughly familiar with all aspects of the installation, and shall be factory-trained in operating theory as well as practical operation and maintenance procedures.

C. A training schedule shall be developed and submitted by the Contractor and approved by the COR at least 30 days prior to the planned training.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

---END---

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SECTION 26 05 13
MEDIUM-VOLTAGE CABLES

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, installation, and connection of medium-voltage cables, indicated as cable or cables in this section, and medium-voltage cable splices and terminations.

1.2 RELATED WORK

A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.

B. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.

C. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits for medium-voltage cables.

D. Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION: Manholes and ducts for medium-voltage cables.

E. Section 26 12 19, PAD-MOUNTED, LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS: Medium-voltage cable terminations for use in pad-mounted, liquid-filled, medium-voltage transformers.

1.3 QUALITY ASSURANCE

A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 FACTORY TESTS

A. Factory Tests shall be required.

B. Factory Tests shall be in accordance with Paragraph, MANUFACTURED PRODUCTS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirement:

1. A representative sample of Medium-voltage cables from each lot shall be factory tested per NEMA WC 74 to ensure that there are no electrical defects in that specific lot of cable.

1.5 SUBMITTALS

A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:

1. Shop Drawings:
   a. Submit sufficient information to demonstrate compliance with drawings and specifications.
   b. Submit the following data for approval:
      1) Complete electrical ratings.
      2) Installation instructions.
2. Samples:
   a. After approval of submittal and prior to installation, Contractor shall furnish sample in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
3. Certifications:
   a. Factory Test Reports: Submit certified factory production test reports for approval.
   b. Field Test Reports: Submit field test reports for approval.
   c. Compatibility: Submit a certificate from the cable manufacturer that the splices and terminations are approved for use with the cable.
   d. Two weeks prior to final inspection, submit the following.
      1) Certification by the manufacturer that the cables, splices, and terminations conform to the requirements of the drawings and specifications.
      2) Certification by the Contractor that the cables, splices, and terminations have been properly installed and tested.
      3) Certification by the Contractor that each splice and each termination were completely installed in a single continuous work period by a single qualified worker without any overnight interruption.
4. Qualified Worker Approval:
   a. Qualified workers who install cables, splices, and terminations shall have a minimum of five years of experience splicing and terminating cables, including experience with the materials in the approved splices and terminations. Qualified workers who perform cable testing shall have a minimum of five year of experience performing electrical testing of medium-voltage cables, including the ability to understand, interpret test results and develop test report.
   b. Furnish satisfactory proof of such experience for each qualified worker who splices or terminates the cables.

1.6 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

B. American Society for Testing and Materials (ASTM):

B3-13(2018).....Standard Specification for Soft or Annealed Copper Wire

C. Institute of Electrical and Electronics Engineers, Inc. (IEEE):

48-20.....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

386-16.....Separable Insulated Connector Systems for Power Distribution Systems above 600 V

400-12.....Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems

400.2-13.....Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF)

404-12.....Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500,000 V

D. National Electrical Manufacturers Association (NEMA):

WC 71-14.....Non-Shielded Cables Rated 2001-5000 Volts for Use in the Distribution of Electric Energy

WC 74-17.....5-46 KV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy

E. National Fire Protection Association (NFPA):

70-23.....National Electrical Code (NEC)

F. Underwriters Laboratories (UL):

1072-06 .....Medium-Voltage Power Cables

1.7 SHIPMENT AND STORAGE

A. Cable shall be shipped on reels such that it is protected against physical, mechanical and environmental damage. Each end of each length of cable shall be hermetically sealed with manufacturer’s end caps and securely attached to the reel.

B. Cable stored and/or cut on site shall have the ends turned down, and sealed with cable manufacturer’s standard cable end seals, or field-installed heat-shrink cable end seals.

PART 2 - PRODUCTS

2.1 CABLE

A. Cable shall be in accordance with ASTM, IEEE, NEC, NEMA and UL, and as shown on the drawings.

B. Single conductor stranded copper conforming to ASTM B3.

C. Voltage Rating:

12. 15,000 V cable shall be used on all distribution systems with voltages ranging from 5,000 V to 15,000 V.

D. Insulation:

1. Insulation level shall be 133%.
2. Types of insulation:
   a. Cable type abbreviation, EPR: Ethylene propylene rubber insulation shall be thermosetting, light and heat stabilized.
   b. Cable type abbreviation, XLP, XLPE, or TR-XLPE: cross-linked polyethylene insulation shall be thermosetting, light and heat stabilized, and chemically cross-linked.

E. Insulation shield shall be semi-conducting. Conductor shield shall be semi-conducting.

F. Insulation shall be wrapped with copper shielding tape, helically-applied over semi-conducting insulation shield.

G. Heavy duty, overall protective polyvinyl chloride jacket shall enclose every cable. The manufacturer's name, cable type and size, and other pertinent information shall be marked or molded clearly on the overall protective jacket.

H. Cable temperature ratings for continuous operation, emergency overload operation, and short circuit operation shall be not less than the NEC, NEMA WC 71, or NEMA WC 74 standard for the respective cable.

2.2 SPLICES AND TERMINATIONS

A. Materials shall be compatible with the cables being spliced and terminated, and shall be suitable for the prevailing environmental conditions.

B. In locations where moisture might be present, the splices shall be watertight. In manholes and pullboxes, the splices shall be submersible.

C. Splices:
   1. Shall comply with IEEE 404. Include all components required for complete splice, with detailed instructions.

D. Terminations:
   1. Shall comply with IEEE 48. Include shield ground strap for shielded cable terminations.
   2. Class 1 terminations for indoor use: Kit with stress-relief tube, molded-silicone rubber insulator modules, and compression-type connector.
   3. Ground metallic cable shields with a device designed for that purpose, consisting of a solderless connector enclosed in watertight rubber housing covering the entire assembly.
   4. Provide insulated cable supports to relieve any strain imposed by cable weight or movement. Ground cable supports to the grounding system.

2.3 FIREPROOFING TAPE

A. Fireproofing tape shall be flexible, non-corrosive, self-extinguishing, arcproof, and fireproof intumescent elastomer. Securing tape shall be glass cloth electrical tape not less than 0.18 mm (7 mils) thick, and 19 mm (0.75 inch) wide.

PART 3 - EXECUTION

3.1 GENERAL

A. Installation shall be in accordance with the NEC, as shown on the drawings, and manufacturer’s instructions.
B. Cable shall be installed in conduit above grade and duct bank below grade.
C. All cables of a feeder shall be pulled simultaneously.
D. Conductors of different systems (e.g., 5kV and 15kV) shall not be installed in the same raceway.
E. Splice the cables only in manholes and pullboxes.
F. Ground shields in accordance with Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.
G. Cable maximum pull length, maximum pulling tension, and minimum bend radius shall conform with the recommendations of the manufacturer.
H. Use suitable lubricating compounds on the cables to prevent pulling damage. Provide compounds that are not injurious to the cable jacket and do not harden or become adhesive.

I. Seal the cable ends prior to pulling, to prevent the entry of moisture or lubricant.

3.2 PROTECTION DURING SPLICING OPERATIONS

A. Blowers shall be provided to force fresh air into manholes where free movement or circulation of air is obstructed. Waterproof protective coverings shall be available on the work site to provide protection against moisture while a splice is being made. Pumps shall be used to keep manholes dry during splicing operations. Under no conditions shall a splice or termination be made that exposes the interior of a cable to moisture. A manhole ring at least 150 mm (6 inches) above ground shall be used around the manhole entrance to keep surface water from entering the manhole. Unused ducts shall be plugged and water seepage through ducts in use shall be stopped before splicing.

3.3 PULLING CABLES IN DUCTS AND MANHOLES

A. Cables shall be pulled into ducts with equipment designed for this purpose, including power-driven winches, cable-feeding flexible tube guides, cable grips, pulling eyes, and lubricants. A sufficient number of qualified workers and equipment shall be employed to ensure the careful and proper installation of the cable.

B. Cable reels shall be set up at the side of the manhole opening and above the duct or hatch level, allowing cables to enter through the opening without reverse bending. Flexible tube guides shall be installed through the opening in a manner that will prevent cables from rubbing on the edges of any structural member.

C. Cable shall be unreeled from the top of the reel. Pay-out shall be carefully controlled. Cables to be pulled shall be attached through a swivel to the main pulling wire by means of a suitable cable grip and pulling eye.

D. Woven-wire cable grips shall be used to grip the cable end when pulling small cables and short straight lengths of heavier cables.

E. Pulling eyes shall be attached to the cable conductors to prevent damage to the cable structure.

F. Cables shall be liberally coated with a suitable lubricant as they enter the tube guide or duct. Rollers, sheaves, or tube guides around which the cable is pulled shall conform to the minimum bending radius of the cable.

G. Cables shall be pulled into ducts at a reasonable speed. Cable pulling using a vehicle shall not be permitted. Pulling operations shall be

stopped immediately at any indication of binding or obstruction, and shall not be resumed until the potential for damage to the cable is corrected. Sufficient slack shall be provided for free movement of cable due to expansion or contraction.

H. Splices in manholes shall be firmly supported on cable racks. Cable ends shall overlap at the ends of a section to provide sufficient undamaged cable for splicing.

I. Cables cut in the field shall have the cut ends immediately sealed to prevent entrance of moisture.

3.4 SPLICES AND TERMINATIONS

A. Install the materials as recommended by the manufacturer, including precautions pertaining to air temperature and humidity during installation.

B. Installation shall be executed by qualified person trained to perform medium-voltage equipment installations. Tools shall be as recommended or provided by the manufacturer. Installation shall comply with manufacturer’s instructions.

C. Splices in manholes shall be located midway between cable racks on walls of manholes, and supported with cable arms at approximately the same elevation as the enclosing duct.

D. Where the Government determines that unsatisfactory splices and terminations have been installed, the Contractor shall replace the unsatisfactory splices and terminations with approved material at no additional cost to the Government.

3.5 FIREPROOFING

A. Cover all cable segments exposed in manholes and pullboxes with fireproofing tape.

B. Apply the tape in a single layer, wrapped in a half-lap manner, or as recommended by the manufacturer. Extend the tape not less than 25 mm (1 inch) into each duct.

C. At each end of a taped cable section, secure the fireproof tape in place with glass cloth tape.

3.6 CIRCUIT IDENTIFICATION OF FEEDERS

A. In each manhole and pullbox, install permanent identification tags on each circuit's cables to clearly designate the circuit identification and voltage. The tags shall be the embossed brass type, 40 mm (1.5 inches) in diameter and 40 mils thick. Attach tags with plastic ties.

Position the tags so they will be easy and clear to read after the fireproofing tape is installed.

3.7 ACCEPTANCE CHECKS AND TESTS

A. General:

1. Perform tests in accordance with the latest IEEE 400 and 400.2, manufacturer's recommendations, and as specified in this specification.
2. Contractor shall make arrangements to have tests witnessed by the COR. Contractor shall proceed with tests only after obtaining approval from the COR.

B. Visual Inspection: Perform visual inspection prior to electrical tests.

1. Inspect exposed sections of cables for physical damage.
2. Inspect shield grounding, cable supports, splices, and terminations.
3. Verify that visible cable bends meet manufacturer’s minimum bending radius requirement.
4. Verify installation of fireproofing tape and identification tags.
5. At the time of final acceptance, Contractor shall provide the COR visual field inspection notes, findings, and photographs detailing accessible inspection locations.

C. Electrical Tests - New Cables: Perform preparation and tests in order shown below:

1. Preparation Prior to Testing: Splices and terminations applied to new cables shall be completed prior to testing. For renovation installation, ends of new cables intended to be spliced to existing service-aged cables shall be prepared (cut back) to allow testing without flashover or tracking. Cables shall not be connected to other equipment while under test.
2. Perform Insulation-Resistance Test. Test all cables with respect to ground and adjacent cables. All adjacent cables shall be grounded during testing.
   a. Apply test voltage for a period sufficient to stabilize output voltage and insulation resistance measurement.
   b. Test data shall include megohm, applied test voltage, and leakage current readings.

c. Further testing shall not continue unless the insulation resistance test results meet or exceed the values listed below. Test voltages and minimum acceptable resistance values shall be:

Voltage Class	Test Voltage	Min. Insulation Resistance
5kV	2,500 VDC	1,000 megohms
15kV	2,500 VDC	5,000 megohms
25kV	5,000 VDC	20,000 megohms
35kV	15,000 VDC	100,000 megohms

3. Perform Tan Delta test. Review test readings with the COR prior to proceeding with the Very Low Frequency (VLF) Withstand test
4. Perform Very Low Frequency (VLF) Withstand test. Utilize test voltages in accordance with IEEE 400.2.

F. Field Test Report: Submit a field test report to the COR that includes the following information:
1. Project Name, Location, Test Date.
2. Name of Technician and Company performing the test.
3. Ambient temperature and humidity at time of test.
.4. Name, Model Number and Description of Test Equipment used.
5. Circuit identification, cable length, cable type and size, insulation type, cable manufacturer, service age (if any), voltage rating, description of splices or terminations.
6. Visual field inspection notes, findings, and photographs.
7. Insulation Resistance Test results:
   a. Test voltage.
   b. Measurement in Megohms.
   c. Leakage current.
8. Tan Delta results:
   a. Test voltage.
   b. Waveform (sinusoidal or cosine-rectangular).
   c. Mean Tan Delta at V_0.
   d. Stability measured by Standard Deviation at V_0.
   e. Differential Tan Delta.
   f. IEEE Condition Assessment Rating.
9. VLF Withstand results:
   a. Test voltage.
   b. Waveform (sinusoidal or cosine-rectangular).
   c. Pass/Fail Rating.

10. Conclusions. If any deficiency is discovered based on test results, provide recommendations for corrective action.

G. Final Acceptance: Final acceptance shall depend upon the satisfactory performance of the cables under test. No cable shall be put into service until all tests are successfully passed, and field test reports have been approved by the COR.

---END---

SECTION 26 05 19
LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, installation, connection, and testing of the electrical conductors and cables for use in electrical systems rated 600 V and below, indicated as cable(s), conductor(s), wire, or wiring in this section.

1.2 RELATED WORK

A. Section 07 84 00, FIRESTOPPING: Sealing around penetrations to maintain the integrity of fire-resistant rated construction.

B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.

C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.

D. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits for conductors and cables.

E. Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION: Installation of conductors and cables in manholes and ducts.

1.3 QUALITY ASSURANCE

A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:

1. Shop Drawings:
   a. Submit sufficient information to demonstrate compliance with drawings and specifications.
   b. Submit the following data for approval:
      1) Electrical ratings and insulation type for each conductor and cable.
      2) Splicing materials and pulling lubricant.

2. Certifications: Two weeks prior to final inspection, submit the following.
   a. Certification by the manufacturer that the conductors and cables conform to the requirements of the drawings and specifications.
   b. Certification by the Contractor that the conductors and cables have been properly installed, adjusted, and tested.

1.5 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent referenced. Publications are reference in the text by designation only.

B. American Society of Testing Material (ASTM):

D2301-10.....Standard Specification for Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape

D2304-18.....Test Method for Thermal Endurance of Rigid Electrical Insulating Materials

D3005-17.....Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape

C. National Electrical Manufacturers Association (NEMA):

WC 70-21.....Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy

D. National Fire Protection Association (NFPA):

70-23.....National Electrical Code (NEC)

E. Underwriters Laboratories, Inc. (UL):

44-18.....Thermoset-Insulated Wires and Cables

83-17.....Thermoplastic-Insulated Wires and Cables

467-13.....Grounding and Bonding Equipment

486A-486B-18.....Wire Connectors

486C-18.....Splicing Wire Connectors

486D-15.....Sealed Wire Connector Systems

486E-15.....Equipment Wiring Terminals for Use with Aluminum and/or Copper Conductors

493-18.....Thermoplastic-Insulated Underground Feeder and Branch Circuit Cables

514B-12.....Conduit, Tubing, and Cable Fittings

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

A. Conductors and cables shall be in accordance with ASTM, NEMA, NFPA, UL, as specified herein, and as shown on the drawings.

B. Conductors shall be copper.

C. Single Conductor:

1. No. 12 AWG: Minimum size, except where smaller sizes are specified herein or shown on the drawings.
2. No. 8 AWG and larger: Stranded.
3. No. 10 AWG and smaller: Solid; except shall be stranded for final connection to motors, transformers, and vibrating equipment.
4. Insulation: THHN-THWN and XHHW-2. XHHW-2 shall be used for isolated power systems.

E. Conductor Color Code:

1. No. 10 AWG and smaller: Solid color insulation or solid color coating.
2. No. 8 AWG and larger: Color-coded using one of the following methods:
   a. Solid color insulation or solid color coating.
   b. Stripes, bands, or hash marks of color specified.
   c. Color using 19 mm (0.75 inches) wide tape.
4. For modifications and additions to existing wiring systems, color coding shall conform to the existing wiring system.
5. Conductors shall be color-coded as follows:

208/120 V	Phase	480/277 V
Black	A	Brown
Red	B	Orange
Blue	C	Yellow
White	Neutral	Gray *
* or white with colored (other than green) tracer.		

6. Lighting circuit “switch legs”, and 3-way and 4-way switch “traveling wires,” shall have color coding that is unique and distinct (e.g., pink and purple) from the color coding indicated above. The unique color codes shall be solid and in accordance with the NEC. Coordinate color coding in the field with the COR.

7. Color code for isolated power system wiring shall be in accordance with the NEC.

2.2 SPLICES

A. Splices shall be in accordance with NEC and UL.

B. Above Ground Splices for No. 10 AWG and Smaller:
   1. Solderless, screw-on, reusable pressure cable type, with integral insulation, approved for copper and aluminum conductors.
   2. The integral insulator shall have a skirt to completely cover the stripped conductors.
   3. The number, size, and combination of conductors used with the connector, as listed on the manufacturer's packaging, shall be strictly followed.

C. Above Ground Splices for No. 8 AWG to No. 4/0 AWG:
   1. Compression, hex screw, or bolt clamp-type of high conductivity and corrosion-resistant material, listed for use with copper and aluminum conductors.
   2. Insulate with materials approved for the particular use, location, voltage, and temperature. Insulation level shall be not less than the insulation level of the conductors being joined.
   3. Splice and insulation shall be product of the same manufacturer.
   4. All bolts, nuts, and washers used with splices shall be zinc-plated.

D. Above Ground Splices for 250 kcmil and Larger:
   1. Long barrel “butt-splice” or “sleeve” type compression connectors, with minimum of two compression indents per wire, listed for use with copper and aluminum conductors.
   2. Insulate with materials approved for the particular use, location, voltage, and temperature. Insulation level shall be not less than the insulation level of the conductors being joined.
   3. Splice and insulation shall be product of the same manufacturer.

E. Plastic electrical insulating tape: Per ASTM D2304, flame-retardant, cold and weather resistant.

2.3 CONNECTORS AND TERMINATIONS

A. Mechanical type of high conductivity and corrosion-resistant material, listed for use with copper and aluminum conductors.

B. Long barrel compression type of high conductivity and corrosion-resistant material, with minimum of two compression indents per wire, listed for use with copper and aluminum conductors.

C. All bolts, nuts, and washers used to connect connections and terminations to bus bars or other termination points shall be zinc-plated.

2.4 CONTROL WIRING

A. Unless otherwise specified elsewhere in these specifications, control wiring shall be as specified herein, except that the minimum size shall be not less than No. 14 AWG, or as required by the control wiring equipment manufacturer.

B. Control wiring shall be sized such that the voltage drop under in-rush conditions does not adversely affect operation of the controls.

2.5 WIRE LUBRICATING COMPOUND

A. Lubricating compound shall be suitable for the wire insulation and conduit, and shall not harden or become adhesive.

B. Shall not be used on conductors for isolated power systems.

PART 3 - EXECUTION

3.1 GENERAL

A. Installation shall be in accordance with the NEC, as shown on the drawings, and manufacturer’s instructions.

B. Install conductors in raceway systems.

C. Splice conductors only in outlet boxes, junction boxes, pullboxes, manholes, or handholes.

D. Conductors of different systems (e.g., 120 V and 277 V) shall not be installed in the same raceway.

E. For conductors installed in vertical raceways, provide conductor support (also known as cable support), to counter gravity pull on conductor weight. Conductor support shall be split-wedge conductor support type. Prior to installing the conductor support plug, remove all pulling compound from conductors where they pass through the conductor support body. After installing the conductor support plug, tap the conductor support plug firmly in the conductor support body.

F. In panelboards, cabinets, wireways, switches, enclosures, and equipment assemblies, neatly form, train, and tie the conductors with non-metallic “zip” ties.

G. For connections to motors, transformers, and vibrating equipment, stranded conductors shall be used only from the last fixed point of connection to the motors, transformers, or vibrating equipment.

H. Use expanding foam or non-hardening duct-seal to seal conduits entering a building, after installation of conductors.

I. Conductor Pulling:

1. Provide installation equipment that will prevent the cutting or abrasion of insulation during pulling. Use lubricants approved for the cable.
2. Use nonmetallic pull ropes.
3. Attach pull ropes by means of either woven basket grips or pulling eyes attached directly to the conductors.
4. All conductors in a single conduit shall be pulled simultaneously.
5. Do not exceed manufacturer’s recommended maximum pulling tensions and sidewall pressure values.

J. Number of conductors for branch circuits shall not exceed more than three branch circuits in any one conduit.

K. When stripping stranded conductors, use a tool that does not damage the conductor or remove conductor strands.

3.2 INSTALLATION IN MANHOLES

A. Train the conductors around the manhole walls, but do not bend to a radius less than six times the overall conductor diameter.

B. Fireproofing:

1. Install fireproofing on low-voltage conductors where the low-voltage conductors are installed in the same manholes with medium-voltage conductors.
2. Use fireproofing tape as specified in Section 26 05 13, MEDIUM-VOLTAGE CABLES, and apply the tape in a single layer, half-lapped, or as recommended by the manufacturer. Install the tape with the coated side towards the cable and extend it not less than 25 mm (1 inch) into each duct.
3. Secure the fireproofing tape in place by a random wrap of glass cloth tape.

3.3 SPLICE AND TERMINATION INSTALLATION

A. Splices and terminations shall be mechanically and electrically secure, and tightened to manufacturer’s published torque values using a torque screwdriver or wrench.

B. Where the Government determines that unsatisfactory splices or terminations have been installed, replace the splices or terminations at no additional cost to the Government.

3.4 CONDUCTOR IDENTIFICATION

A. When using colored tape to identify phase, neutral, and ground conductors larger than No. 8 AWG, apply tape in half-overlapping turns for a minimum of 75 mm (3 inches) from terminal points, and in junction boxes, pullboxes, and manholes. Apply the last two laps of tape with no tension to prevent possible unwinding. Where markings are covered by tape, apply tags to conductors, stating size and insulation type.

3.5 FEEDER CONDUCTOR IDENTIFICATION

A. In each interior pullbox and each underground manhole and handhole, install brass tags on all feeder conductors to clearly designate their circuit identification and voltage. The tags shall be the embossed type, 40 mm (1-1/2 inches) in diameter and 40 mils thick. Attach tags with plastic ties.

3.6 EXISTING CONDUCTORS

A. Unless specifically indicated on the plans, existing conductors shall not be reused.

3.7 CONTROL WIRING INSTALLATION

A. Unless otherwise specified in other sections, install control wiring and connect to equipment to perform the required functions as specified or as shown on the drawings.

B. Install a separate power supply circuit for each system, except where otherwise shown on the drawings.

3.8 CONTROL WIRING IDENTIFICATION

A. Install a permanent wire marker on each wire at each termination.
B. Identifying numbers and letters on the wire markers shall correspond to those on the wiring diagrams used for installing the systems.
C. Wire markers shall retain their markings after cleaning.
D. In each manhole and handhole, install embossed brass tags to identify the system served and function.

3.09 ACCEPTANCE CHECKS AND TESTS

A. Perform in accordance with the manufacturer's recommendations. In addition, include the following:
   1. Visual Inspection and Tests: Inspect physical condition.
   2. Electrical tests:
      a. After installation but before connection to utilization devices, such as fixtures, motors, or appliances, test conductors phase-

to-phase and phase-to-ground resistance with an insulation resistance tester. Existing conductors to be reused shall also be tested.

b. Applied voltage shall be 500 V DC for 300 V rated cable, and 1000 V DC for 600 V rated cable. Apply test for one minute or until reading is constant for 15 seconds, whichever is longer. Minimum insulation resistance values shall not be less than 25 megohms for 300 V rated cable and 100 megohms for 600 V rated cable.

c. Perform phase rotation test on all three-phase circuits.

---END---

SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, installation, connection, and testing of grounding and bonding equipment, indicated as grounding equipment in this section.

B. "Grounding electrode system" refers to grounding electrode conductors and all electrodes required or allowed by NEC, as well as made, supplementary, and lightning protection system grounding electrodes.

C. The terms "connect" and "bond" are used interchangeably in this section and have the same meaning.

1.2 RELATED WORK

A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.

B. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Low-voltage conductors.

C. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduit and boxes.

D. Section 26 12 19, PAD-MOUNTED, LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS: pad-mounted, liquid-filled, medium-voltage transformers.

E. Section 26 13 16, MEDIUM-VOLTAGE FUSIBLE INTERRUPTER SWITCHES: Medium-voltage fusible interrupter switches.

F. Section 26 22 00, LOW-VOLTAGE TRANSFORMERS: Low-voltage transformers.

G. Section 26 24 13, DISTRIBUTION SWITCHBOARDS: Low-voltage distribution switchboards.

H. Section 26 24 16, PANELBOARDS: Low-voltage panelboards.

I. Section 26 32 13, ENGINE GENERATORS: Engine generators.

J. Section 26 36 23, AUTOMATIC TRANSFER SWITCHES: Automatic transfer switches.

K. Section 26 41 00, FACILITY LIGHTNING PROTECTION: Lightning protection.

1.3 QUALITY ASSURANCE

A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:

1. Shop Drawings:
   a. Submit sufficient information to demonstrate compliance with drawings and specifications.
   b. Submit plans showing the location of system grounding electrodes and connections, and the routing of aboveground and underground grounding electrode conductors.
2. Test Reports:
   a. Two weeks prior to the final inspection, submit ground resistance field test reports to the COR.
3. Certifications:
   a. Certification by the Contractor that the grounding equipment has been properly installed and tested.

1.5 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

B. American Society for Testing and Materials (ASTM):

B1-13.....Standard Specification for Hard-Drawn Copper Wire

B3-13(R2018).....Standard Specification for Soft or Annealed Copper Wire

B8-11(R2017).....Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

C. Institute of Electrical and Electronics Engineers, Inc. (IEEE):

81-12.....IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System Part 1: Normal Measurements

D. National Fire Protection Association (NFPA):

70-23.....National Electrical Code (NEC)

70E-21.....National Electrical Safety Code

99-21.....Health Care Facilities

E. Underwriters Laboratories, Inc. (UL):

44-18 .....Thermoset-Insulated Wires and Cables

83-17 .....Thermoplastic-Insulated Wires and Cables

467-13 .....Grounding and Bonding Equipment

PART 2 - PRODUCTS

2.1 GROUNDING AND BONDING CONDUCTORS

A. Equipment grounding conductors shall be insulated stranded copper, except that sizes No. 10 AWG and smaller shall be solid copper. Insulation color shall be continuous green for all equipment grounding conductors, except that wire sizes No. 4 AWG and larger shall be identified per NEC.

B. Bonding conductors shall be bare stranded copper, except that sizes No. 10 AWG and smaller shall be bare solid copper. Bonding conductors shall be stranded for final connection to motors, transformers, and vibrating equipment.

C. Conductor sizes shall not be less than shown on the drawings, or not less than required by the NEC, whichever is greater.

D. Insulation: THHN-THWN and XHHW-2. XHHW-2 shall be used for isolated power systems.

2.2 GROUND RODS

A. Steel or copper clad steel, 19 mm (0.75 inch) diameter by 3 M (10 feet) long.

B. Quantity of rods shall be as shown on the drawings, and as required to obtain the specified ground resistance.

2.3 CONCRETE ENCASED ELECTRODE

A. Concrete encased electrode shall be No. 4 AWG bare copper wire, installed per NEC.

2.4 GROUND CONNECTIONS

A. Below Grade and Inaccessible Locations: Exothermic-welded type connectors.

B. Above Grade:

1. Bonding Jumpers: Listed for use with aluminum and copper conductors. For wire sizes No. 8 AWG and larger, use compression-type connectors. For wire sizes smaller than No. 8 AWG, use mechanical type lugs. Connectors or lugs shall use zinc-plated steel bolts, nuts, and washers. Bolts shall be torqued to the values recommended by the manufacturer.
2. Connection to Building Steel: Exothermic-welded type connectors.

3. Connection to Grounding Bus Bars: Listed for use with aluminum and copper conductors. Use mechanical type lugs, with zinc-platedsteel bolts, nuts, and washers. Bolts shall be torqued to the values recommended by the manufacturer.
4. Connection to Equipment Rack and Cabinet Ground Bars: Listed for use with aluminum and copper conductors. Use mechanical type lugs, with zinc-plated steel bolts, nuts, and washers. Bolts shall be torqued to the values recommended by the manufacturer.

2.5 EQUIPMENT RACK AND CABINET GROUND BARS

A. Provide solid copper ground bars designed for mounting on the framework of open or cabinet-enclosed equipment racks. Ground bars shall have minimum dimensions of 6.3 mm (0.25 inch) thick x 19 mm (0.75 inch) wide, with length as required or as shown on the drawings. Provide insulators and mounting brackets.

2.6 GROUND TERMINAL BLOCKS

A. At any equipment mounting location (e.g., backboards and hinged cover enclosures) where rack-type ground bars cannot be mounted, provide mechanical type lugs, with zinc-platedsteel bolts, nuts, and washers. Bolts shall be torqued to the values recommended by the manufacturer.

2.7 GROUNDING BUS BAR

A. Pre-drilled rectangular copper bar with stand-off insulators, minimum 6.3 mm (0.25 inch) thick x 100 mm (4 inches) high in cross-section, length as shown on the drawings, with hole size, quantity, and spacing per detail shown on the drawings. Provide insulators and mounting brackets.

PART 3 - EXECUTION

3.1 GENERAL

A. Installation shall be in accordance with the NEC, as shown on the drawings, and manufacturer’s instructions.

B. System Grounding:
1. Secondary service neutrals: Ground at the supply side of the secondary disconnecting means and at the related transformer.
2. Separately derived systems (transformers downstream from the service entrance): Ground the secondary neutral.

C. Equipment Grounding: Metallic piping, building structural steel, electrical enclosures, raceways, junction boxes, outlet boxes,

cabinets, machine frames, and other conductive items in close proximity with electrical circuits, shall be bonded and grounded.

D. For patient care area electrical power system grounding, conform to the latest NFPA 70 and 99.

3.2 INACCESSIBLE GROUNDING CONNECTIONS

A. Make grounding connections, which are normally buried or otherwise inaccessible, by exothermic weld.

3.3 MEDIUM-VOLTAGE EQUIPMENT AND CIRCUITS

A. Duct Banks and Manholes: Provide an insulated equipment grounding conductor in each duct containing medium-voltage conductors, sized per NEC except that minimum size shall be No. 2 AWG. Bond the equipment grounding conductors to the switchgear ground bus, to all manhole grounding provisions and hardware, to the cable shield grounding provisions of medium-voltage cable splices and terminations, and to equipment enclosures.

B. Pad-Mounted Transformers:

1. Provide a driven ground rod and bond with a grounding electrode conductor to the transformer grounding pad.
2. Ground the secondary neutral.

C. Lightning Arresters: Connect lightning arresters to the equipment ground bus or ground rods as applicable.

3.4 SECONDARY VOLTAGE EQUIPMENT AND CIRCUITS

A. Main Bonding Jumper: Bond the secondary service neutral to the ground bus in the service equipment.

B. Metallic Piping, Building Structural Steel, and Supplemental Electrode(s):

1. Provide a grounding electrode conductor sized per NEC between the service equipment ground bus and all metallic water pipe systems, building structural steel, and supplemental or made electrodes. Provide jumpers across insulating joints in the metallic piping.
2. Provide a supplemental ground electrode as shown on the drawings and bond to the grounding electrode system.

C. Switchgear, Switchboards, Unit Substations, Panelboards, Motor Control Centers, Engine-Generators, Automatic Transfer Switches, and other electrical equipment:

1. Connect the equipment grounding conductors to the ground bus.

2. Connect metallic conduits by grounding bushings and equipment grounding conductor to the equipment ground bus.

D. Transformers:

1. Exterior: Exterior transformers supplying interior service equipment shall have the neutral grounded at the transformer secondary. Provide a grounding electrode at the transformer.
2. Separately derived systems (transformers downstream from service equipment): Ground the secondary neutral at the transformer. Provide a grounding electrode conductor from the transformer to the nearest component of the grounding electrode system.

3.5 RACEWAY

A. Conduit Systems:

1. Ground all metallic conduit systems. All metallic conduit systems shall contain an equipment grounding conductor.
2. Non-metallic conduit systems, except non-metallic feeder conduits that carry a grounded conductor from exterior transformers to interior or building-mounted service entrance equipment, shall contain an equipment grounding conductor.
3. Metallic conduit that only contains a grounding conductor, and is provided for its mechanical protection, shall be bonded to that conductor at the entrance and exit from the conduit.
4. Metallic conduits which terminate without mechanical connection to an electrical equipment housing by means of locknut and bushings or adapters, shall be provided with grounding bushings. Connect bushings with a equipment grounding conductor to the equipment ground bus.

B. Feeders and Branch Circuits: Install equipment grounding conductors with all feeders, and all branch circuits.

C. Boxes, Cabinets, Enclosures, and Panelboards:

1. Bond the equipment grounding conductor to each pullbox, junction box, outlet box, device box, cabinets, and other enclosures through which the conductor passes (except for special grounding systems for intensive care units and other critical units shown).
2. Provide lugs in each box and enclosure for equipment grounding conductor termination.

D. Wireway Systems:

1. Bond the metallic structures of wireway to provide electrical continuity throughout the wireway system, by connecting a No. 6 AWG

bonding jumper at all intermediate metallic enclosures and across all section junctions.

2. Install insulated No. 6 AWG bonding jumpers between the wireway system, bonded as required above, and the closest building ground at each end and approximately every 16 M (50 feet).
3. Use insulated No. 6 AWG bonding jumpers to ground or bond metallic wireway at each end for all intermediate metallic enclosures and across all section junctions.
4. Use insulated No. 6 AWG bonding jumpers to ground cable tray to column-mounted building ground plates (pads) at each end and approximately every 15 M (49 feet).

E. Receptacles shall not be grounded through their mounting screws. Ground receptacles with a jumper from the receptacle green ground terminal to the device box ground screw and a jumper to the branch circuit equipment grounding conductor.

F. Ground lighting fixtures to the equipment grounding conductor of the wiring system. Fixtures connected with flexible conduit shall have a green ground wire included with the power wires from the fixture through the flexible conduit to the first outlet box.

G. Fixed electrical appliances and equipment shall be provided with a ground lug for termination of the equipment grounding conductor.

H. Raised Floors: Provide bonding for all raised floor components as shown on the drawings.

I. Panelboard Bonding in Patient Care Areas: The equipment grounding terminal buses of the normal and essential branch circuit panel boards serving the same individual patient vicinity shall be bonded together with an insulated continuous copper conductor not less than No. 10 AWG, installed in rigid metal conduit.

3.6 OUTDOOR METALLIC FENCES AROUND ELECTRICAL EQUIPMENT

A. Fences shall be grounded as shown on the drawings.

B. Drive ground rods until the top is 300 mm (12 inches) below grade. Attach a No. 4 AWG copper conductor by exothermic weld to the ground rods, and extend underground to the immediate vicinity of fence post. Lace the conductor vertically into 300 mm (12 inches) of fence mesh and fasten by two approved bronze compression fittings, one to bond the wire to post and the other to bond the wire to fence. Each gate section shall be bonded to its gatepost by a 3 mm x 25 mm (0.375 inch x 1 inch)

flexible, braided copper strap and ground post clamps. Clamps shall be of the anti-electrolysis type.

3.7 CORROSION INHIBITORS

A. When making grounding and bonding connections, apply a corrosion inhibitor to all contact surfaces. Use corrosion inhibitor appropriate for protecting a connection between the metals used.

3.8 CONDUCTIVE PIPING

A. Bond all conductive piping systems, interior and exterior, to the grounding electrode system. Bonding connections shall be made as close as practical to the equipment ground bus.

B. In operating rooms and at intensive care and coronary care type beds, bond the medical gas piping and medical vacuum piping at the outlets directly to the patient ground bus.

3.9 LIGHTNING PROTECTION SYSTEM

A. Bond the lightning protection system to the electrical grounding electrode system.

3.10 MAIN ELECTRICAL ROOM GROUNDING

A. Provide ground bus bar and mounting hardware at each main electrical room where incoming feeders are terminated, as shown on the drawings. Connect to pigtail extensions of the building grounding ring, as shown on the drawings.

3.11 EXTERIOR LIGHT POLES

A. Provide 6.1 M (20 feet) of No. 4 AWG bare copper coiled at bottom of pole base excavation prior to pour, plus additional un-spliced length in and above foundation as required to reach pole ground stud.

3.12 GROUND RESISTANCE

A. Grounding system resistance to ground shall not exceed 5 ohms. Make any modifications or additions to the grounding electrode system necessary for compliance without additional cost to the Government. Final tests shall ensure that this requirement is met.

B. Grounding system resistance shall comply with the electric utility company ground resistance requirements.

3.13 GROUND ROD INSTALLATION

A. For outdoor installations, drive each rod vertically in the earth, until top of rod is 610 mm (24 inches) below final grade.

B. For indoor installations, leave 100 mm (4 inches) of each rod exposed.

C. Where buried or permanently concealed ground connections are required, make the connections by the exothermic process, to form solid metal joints. Make accessible ground connections with mechanical pressure-type ground connectors.

D. Where rock or impenetrable soil prevents the driving of vertical ground rods, install angled ground rods or grounding electrodes in horizontal trenches to achieve the specified ground resistance.

3.14 ACCEPTANCE CHECKS AND TESTS

A. Resistance of the grounding electrode system shall be measured using a four-terminal fall-of-potential method as defined in IEEE 81. Ground resistance measurements shall be made before the electrical distribution system is energized or connected to the electric utility company ground system, and shall be made in normally dry conditions not fewer than 48 hours after the last rainfall.

B. Resistance measurements of separate grounding electrode systems shall be made before the systems are bonded together. The combined resistance of separate systems may be used to meet the required resistance, but the specified number of electrodes must still be provided.

C. Below-grade connections shall be visually inspected by the COR prior to backfilling. The Contractor shall notify the COR 24 hours before the connections are ready for inspection.

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SECTION 26 05 33
RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, installation, and connection of conduit, fittings, and boxes, to form complete, coordinated, grounded raceway systems. Raceways are required for all wiring unless shown or specified otherwise.

B. Definitions: The term conduit, as used in this specification, shall mean any or all of the raceway types specified.

1.2 RELATED WORK

A. Section 06 10 00, ROUGH CARPENTRY: Mounting board for telephone closets.

B. Section 07 60 00, FLASHING AND SHEET METAL: Fabrications for the deflection of water away from the building envelope at penetrations.

C. Section 07 84 00, FIRESTOPPING: Sealing around penetrations to maintain the integrity of fire rated construction.

D. Section 07 92 00, JOINT SEALANTS: Sealing around conduit penetrations through the building envelope to prevent moisture migration into the building.

E. Section 09 91 00, PAINTING: Identification and painting of conduit and other devices.

F. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS: Conduits bracing.

G. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements and items that are common to more than one section of Division 26.

H. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.

I. Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION: Underground conduits.

J. Section 31 20 00, EARTHWORK: Bedding of conduits.

1.3 QUALITY ASSURANCE

A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:

1. Shop Drawings:
   a. Size and location of main feeders.
   b. Size and location of panels and pull-boxes.
   c. Layout of required conduit penetrations through structural elements.
   d. Submit the following data for approval:
      1) Raceway types and sizes.
      2) Conduit bodies, connectors and fittings.
      3) Junction and pull boxes, types and sizes.
2. Certifications: Two weeks prior to final inspection, submit the following:
   a. Certification by the manufacturer that raceways, conduits, conduit bodies, connectors, fittings, junction and pull boxes, and all related equipment conform to the requirements of the drawings and specifications.
   b. Certification by the Contractor that raceways, conduits, conduit bodies, connectors, fittings, junction and pull boxes, and all related equipment have been properly installed.

1.5 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

B. American Iron and Steel Institute (AISI):

S100-16.....North American Specification for the Design of Cold-Formed Steel Structural Members

C. National Electrical Manufacturers Association (NEMA):

C80.1-20.....Electrical Rigid Steel Conduit

C80.3-20.....Steel Electrical Metal Tubing

C80.6-18.....Electrical Intermediate Metal Conduit

FB1-14.....Fittings, Cast Metal Boxes and Conduit Bodies for Conduit, Electrical Metallic Tubing and Cable

FB2.10-21.....Selection and Installation Guidelines for Fittings for use with Non-Flexible Conduit or Tubing (Rigid Metal Conduit, Intermediate Metallic Conduit, and Electrical Metallic Tubing)

FB2.20-21.....Selection and Installation Guidelines for Fittings for use with Flexible Electrical Conduit and Cable

TC-2-20.....Electrical Polyvinyl Chloride (PVC) Tubing and Conduit

TC-3-21.....PVC Fittings for Use with Rigid PVC Conduit and Tubing

D. National Fire Protection Association (NFPA):

70-23.....National Electrical Code (NEC)

E. Underwriters Laboratories, Inc. (UL):

1-05.....Flexible Metal Conduit

5-16.....Surface Metal Raceway and Fittings

6-07.....Electrical Rigid Metal Conduit - Steel

50-15.....Enclosures for Electrical Equipment

360-13.....Liquid-Tight Flexible Steel Conduit

467-13.....Grounding and Bonding Equipment

514A-13.....Metallic Outlet Boxes

514B-12.....Conduit, Tubing, and Cable Fittings

514C-14.....Nonmetallic Outlet Boxes, Flush-Device Boxes and Covers

651-11.....Schedule 40 and 80 Rigid PVC Conduit and Fittings

651A-11.....Type EB and A Rigid PVC Conduit and HDPE Conduit

797-07.....Electrical Metallic Tubing

1242-06.....Electrical Intermediate Metal Conduit - Steel

PART 2 - PRODUCTS

2.1 MATERIAL

A. Conduit Size: In accordance with the NEC, but not less than 13 mm (0.5-inch) unless otherwise shown. Where permitted by the NEC, 13 mm (0.5-inch) flexible conduit may be used for tap connections to recessed lighting fixtures.

B. Conduit:

1. Size: In accordance with the NEC, but not less than 13 mm (0.5-inch).
2. Rigid Steel Conduit (RMC): Shall conform to UL 6 and NEMA C80.1.
3. Rigid Intermediate Steel Conduit (IMC): Shall conform to UL 1242 and NEMA C80.6.
4. Electrical Metallic Tubing (EMT): Shall conform to UL 797 and NEMA C80.3. Maximum size not to exceed 105 mm (4 inches) and shall be permitted only with cable rated 600 V or less.
5. Flexible Metal Conduit: Shall conform to UL 1.
6. Liquid-tight Flexible Metal Conduit: Shall conform to UL 360.
7. Direct Burial Plastic Conduit: Shall conform to UL 651 and UL 651A, heavy wall PVC or high density polyethylene (PE).
8. Surface Metal Raceway: Shall conform to UL 5.

C. Conduit Fittings:
   1. Rigid Steel and Intermediate Metallic Conduit Fittings:
      a. Fittings shall meet the requirements of UL 514B and NEMA FB1.
      b. Standard threaded couplings, locknuts, bushings, conduit bodies, and elbows: Only steel or malleable iron materials are acceptable. Integral retractable type IMC couplings are also acceptable.
      c. Locknuts: Bonding type with sharp edges for digging into the metal wall of an enclosure.
      d. Bushings: Metallic insulating type, consisting of an insulating insert, molded or locked into the metallic body of the fitting. Bushings made entirely of metal or nonmetallic material are not permitted.
      e. Erickson (Union-Type) and Set Screw Type Couplings: Approved for use in concrete are permitted for use to complete a conduit run where conduit is installed in concrete. Use set screws of case-hardened steel with hex head and cup point to firmly seat in conduit wall for positive ground. Tightening of set screws with pliers is prohibited.
      f. Sealing Fittings: Threaded cast iron type. Use continuous drain-type sealing fittings to prevent passage of water vapor. In concealed work, install fittings in flush steel boxes with blank cover plates having the same finishes as that of other electrical plates in the room.

2. Electrical Metallic Tubing Fittings:
   a. Fittings and conduit bodies shall meet the requirements of UL 514B, NEMA C80.3, and NEMA FB1.
   b. Only steel or malleable iron materials are acceptable.

   c. Set Screw Couplings and Connectors: Use setscrews of case-hardened steel with hex head and cup point, to firmly seat in wall of conduit for positive grounding. Connector shall have insulated throat.
   d. Indent-type connectors or couplings are prohibited.
   e. Die-cast or pressure-cast zinc-alloy fittings or fittings made of "pot metal" are prohibited.
3. Flexible Metal Conduit Fittings:
   a. Conform to UL 514B. Only steel or malleable iron materials are acceptable.
   b. Clamp-type, with insulated throat.
4. Liquid-tight Flexible Metal Conduit Fittings:
   a. Fittings shall meet the requirements of UL 514B and NEMA FB1.
   b. Only steel or malleable iron materials are acceptable.
   c. Fittings must incorporate a threaded grounding cone, a steel or plastic compression ring, and a gland for tightening. Connectors shall have insulated throats.
5. Direct Burial Plastic Conduit Fittings: Fittings shall meet the requirements of UL 514C and NEMA TC3.
6. Surface Metal Raceway Fittings: As recommended by the raceway manufacturer. Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, conduit entry fittings, accessories, and other fittings as required for complete system.
7. Expansion and Deflection Couplings:
   a. Conform to UL 467 and UL 514B.
   b. Accommodate a 19 mm (0.75-inch) deflection, expansion, or contraction in any direction, and allow 30 degree angular deflections.
   c. Include internal flexible metal braid, sized to guarantee conduit ground continuity and a low-impedance path for fault currents, in

accordance with UL 467 and the NEC tables for equipment grounding conductors.

d. Jacket: Flexible, corrosion-resistant, watertight, moisture and heat-resistant molded rubber material with stainless steel jacket clamps.

D. Conduit Supports:

1. Parts and Hardware: Zinc-coat or provide equivalent corrosion protection.
2. Individual Conduit Hangers: Designed for the purpose, having a pre-assembled closure bolt and nut, and provisions for receiving a hanger rod.
3. Multiple Conduit (Trapeze) Hangers: Not less than 38 mm x 38 mm (1.5 x 1.5 inches), 12-gauge steel, cold-formed, lipped channels; with not less than 9 mm (0.375-inch) diameter steel hanger rods.
4. Solid Masonry and Concrete Anchors: Self-drilling expansion shields, or machine bolt expansion.

E. Outlet, Junction, and Pull Boxes:

1. Comply with UL-50 and UL-514A.
2. Rustproof cast metal where required by the NEC or shown on drawings.
3. Sheet Metal Boxes: Galvanized steel, except where shown on drawings.

F. Metal Wireways: Equip with hinged covers, except as shown on drawings. Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for a complete system.

PART 3 - EXECUTION

3.1 PENETRATIONS

A. Cutting or Holes:

1. Cut holes in advance where they should be placed in the structural elements, such as ribs or beams. Obtain the approval of the COR prior to drilling through structural elements.
2. Cut holes through concrete and masonry in new and existing structures with a diamond core drill or concrete saw. Pneumatic hammers, impact electric, hand, or manual hammer-type drills are not allowed, except when permitted by the COR where working space is limited.

B. Firestop: Where conduits, wireways, and other electrical raceways pass through fire partitions, fire walls, smoke partitions, or floors, install a fire stop that provides an effective barrier against the spread of fire, smoke and gases as specified in Section 07 84 00, FIRESTOPPING.

C. Waterproofing: At floor, exterior wall, and roof conduit penetrations, completely seal the gap around conduit to render it watertight, as specified in Section 07 92 00, JOINT SEALANTS.

3.2 INSTALLATION, GENERAL

A. In accordance with NEC, NEMA, UL, as shown on drawings, and as specified herein.

B. Raceway systems used for Essential Electrical Systems (EES) shall be entirely independent of other raceway systems.

C. Install conduit as follows:

1. In complete mechanically and electrically continuous runs before pulling in cables or wires.
2. Unless otherwise indicated on the drawings or specified herein, installation of all conduits shall be concealed within finished walls, floors, and ceilings.
3. Flattened, dented, or deformed conduit is not permitted. Remove and replace the damaged conduits with new conduits.
4. Assure conduit installation does not encroach into the ceiling height head room, walkways, or doorways.
5. Cut conduits square, ream, remove burrs, and draw up tight.
6. Independently support conduit at 2.4 M (8 feet) on centers with specified materials and as shown on drawings.
7. Do not use suspended ceilings, suspended ceiling supporting members, lighting fixtures, other conduits, cable tray, boxes, piping, or ducts to support conduits and conduit runs.
8. Support within 300 mm (12 inches) of changes of direction, and within 300 mm (12 inches) of each enclosure to which connected.
9. Close ends of empty conduits with plugs or caps at the rough-in stage until wires are pulled in, to prevent entry of debris.
10. Conduit installations under fume and vent hoods are prohibited.
11. Secure conduits to cabinets, junction boxes, pull-boxes, and outlet boxes with bonding type locknuts. For rigid steel and IMC conduit installations, provide a locknut on the inside of the enclosure,

made up wrench tight. Do not make conduit connections to junction box covers.

12. Flashing of penetrations of the roof membrane is specified in Section 07 60 00, FLASHING AND SHEET METAL.
13. Conduit bodies shall only be used for changes in direction, and shall not contain splices.

D. Conduit Bends:
   1. Make bends with standard conduit bending machines.
   2. Conduit hickey may be used for slight offsets and for straightening stubbed out conduits.
   3. Bending of conduits with a pipe tee or vise is prohibited.

E. Layout and Homeruns:
   1. Install conduit with wiring, including homeruns, as shown on drawings.
   2. Deviations: Make only where necessary to avoid interferences and only after drawings showing the proposed deviations have been submitted and approved by the COR.

3.3 CONCEALED WORK INSTALLATION

A. In Concrete:
   1. Conduit: Rigid steel, IMC, or EMT. Do not install EMT in concrete slabs that are in contact with soil, gravel, or vapor barriers.
   2. Align and run conduit in direct lines.
   3. Install conduit through concrete beams only:
      a. Where shown on the structural drawings.
      b. As approved by the COR prior to construction, and after submittal of drawing showing location, size, and position of each penetration.
   4. Installation of conduit in concrete that is less than 75 mm (3 inches) thick is prohibited.
      a. Conduit outside diameter larger than one-third of the slab thickness is prohibited.
      b. Space between conduits in slabs: Approximately six conduit diameters apart, and one conduit diameter at conduit crossings.
      c. Install conduits approximately in the center of the slab so that there will be a minimum of 19 mm (0.75-inch) of concrete around the conduits.

5. Make couplings and connections watertight. Use thread compounds that are UL approved conductive type to ensure low resistance ground continuity through the conduits. Tightening setscrews with pliers is prohibited.

B. Above Furred or Suspended Ceilings and in Walls:
1. Conduit for Conductors Above 600 V: Rigid steel. Mixing different types of conduits in the same system is prohibited.
2. Conduit for Conductors 600 V and Below: Rigid steel, IMC, or EMT. Mixing different types of conduits in the same system is prohibited.
3. Align and run conduit parallel or perpendicular to the building lines.
4. Connect recessed lighting fixtures to conduit runs with maximum 1.8 M (6 feet) of flexible metal conduit extending from a junction box to the fixture.
5. Tightening set screws with pliers is prohibited.
6. For conduits running through metal studs, limit field cut holes to no more than 70% of web depth. Spacing between holes shall be at least 457 mm (18 inches). Cuts or notches in flanges or return lips shall not be permitted.

3.4 EXPOSED WORK INSTALLATION

A. Unless otherwise indicated on drawings, exposed conduit is only permitted in mechanical and electrical rooms.

B. Conduit for Conductors Above 600 V: Rigid steel. Mixing different types of conduits in the system is prohibited.
C. Conduit for Conductors 600 V and Below: Rigid steel, IMC, or EMT. Mixing different types of conduits in the system is prohibited.
D. Align and run conduit parallel or perpendicular to the building lines.
E. Install horizontal runs close to the ceiling or beams and secure with conduit straps.
F. Support horizontal or vertical runs at not over 2.4 M (8 feet) intervals.
G. Surface Metal Raceways: Use only where shown on drawings.
H. Painting:
1. Paint exposed conduit as specified in Section 09 91 00, PAINTING.
2. Paint all conduits containing cables rated over 600 V safety orange. Refer to Section 09 91 00, PAINTING for preparation, paint type, and exact color. In addition, paint legends, using 50 mm (2 inch) high

black numerals and letters, showing the cable voltage rating. Provide legends where conduits pass through walls and floors and at maximum 6 M (20 feet) intervals in between.

3.5 DIRECT BURIAL INSTALLATION

Refer to Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION.

3.6 HAZARDOUS LOCATIONS

A. Use rigid steel conduit only.

B. Install UL approved sealing fittings that prevent passage of explosive vapors in hazardous areas equipped with explosion-proof lighting fixtures, switches, and receptacles, as required by the NEC.

3.7 WET OR DAMP LOCATIONS

A. Use rigid steel or IMC conduits unless as shown on drawings.

B. Provide sealing fittings to prevent passage of water vapor where conduits pass from warm to cold locations, i.e., refrigerated spaces, constant-temperature rooms, air-conditioned spaces, building exterior walls, roofs, or similar spaces.

C. Use rigid steel or IMC conduit within 1.5 M (5 feet) of the exterior and below concrete building slabs in contact with soil, gravel, or vapor barriers, unless as shown on drawings. Conduit shall be half-lapped with 10 mil PVC tape before installation. After installation, completely recoat or retape any damaged areas of coating.

D. Conduits run on roof shall be supported with integral galvanized lipped steel channel, attached to UV-inhibited polycarbonate or polypropylene blocks every 2.4 M (8 feet) with 9 mm (3/8-inch) galvanized threaded rods, square washer and locknut. Conduits shall be attached to steel channel with conduit clamps.

3.8 MOTORS AND VIBRATING EQUIPMENT

A. Use flexible metal conduit for connections to motors and other electrical equipment subject to movement, vibration, misalignment, cramped quarters, or noise transmission.

B. Use liquid-tight flexible metal conduit for installation in exterior locations, moisture or humidity laden atmosphere, corrosive atmosphere, water or spray wash-down operations, inside airstream of HVAC units, and locations subject to seepage or dripping of oil, grease, or water.

C. Provide a green equipment grounding conductor with flexible and liquid-tight flexible metal conduit.

3.9 EXPANSION JOINTS

A. Conduits 75 mm (3 inch) and larger that are secured to the building structure on opposite sides of a building expansion joint require expansion and deflection couplings. Install the couplings in accordance with the manufacturer's recommendations.

B. Provide conduits smaller than 75 mm (3 inch) with junction boxes on both sides of the expansion joint. Connect flexible metal conduits to junction boxes with sufficient slack to produce a 125 mm (5 inch) vertical drop midway between the ends of the flexible metal conduit. Flexible metal conduit shall have a green insulated copper bonding jumper installed. In lieu of this flexible metal conduit, expansion and deflection couplings as specified above are acceptable.

C. Install expansion and deflection couplings where shown.

3.10 CONDUIT SUPPORTS

A. Safe working load shall not exceed one-quarter of proof test load of fastening devices.

B. Use pipe straps or individual conduit hangers for supporting individual conduits.

C. Support multiple conduit runs with trapeze hangers. Use trapeze hangers that are designed to support a load equal to or greater than the sum of the weights of the conduits, wires, hanger itself, and an additional 90 kg (200 lbs). Attach each conduit with U-bolts or other approved fasteners.

D. Support conduit independently of junction boxes, pull-boxes, fixtures, suspended ceiling T-bars, angle supports, and similar items.

E. Fasteners and Supports in Solid Masonry and Concrete:

1. New Construction: Use steel or malleable iron concrete inserts set in place prior to placing the concrete.
2. Existing Construction:
   a. Steel expansion anchors not less than 6 mm (0.25-inch) bolt size and not less than 28 mm (1.125 inch) in embedment.
   b. Power set fasteners not less than 6 mm (0.25-inch) diameter with depth of penetration not less than 75 mm (3 inch).
   c. Use vibration and shock-resistant anchors and fasteners for attaching to concrete ceilings.

F. Hollow Masonry: Toggle bolts.

G. Bolts supported only by plaster or gypsum wallboard are not acceptable.

H. Metal Structures: Use machine screw fasteners or other devices specifically designed and approved for the application.

I. Attachment by wood plugs, rawl plug, plastic, lead or soft metal anchors, or wood blocking and bolts supported only by plaster is prohibited.

J. Chain, wire, or perforated strap shall not be used to support or fasten conduit.

K. Spring steel type supports or fasteners are prohibited for all uses except horizontal and vertical supports/fasteners within walls.

L. Vertical Supports: Vertical conduit runs shall have riser clamps and supports in accordance with the NEC and as shown. Provide supports for cable and wire with fittings that include internal wedges and retaining collars.

3.11 BOX INSTALLATION

A. Boxes for Concealed Conduits:
   1. Flush-mounted.
   2. Provide raised covers for boxes to suit the wall or ceiling, construction, and finish.

B. In addition to boxes shown, install additional boxes where needed to prevent damage to cables and wires during pulling-in operations or where more than the equivalent of 4-90 degree bends are necessary.

C. Locate pullboxes so that covers are accessible and easily removed. Coordinate locations with piping and ductwork where installed above ceilings.

D. Remove only knockouts as required. Plug unused openings. Use threaded plugs for cast metal boxes and snap-in metal covers for sheet metal boxes.

E. Outlet boxes mounted back-to-back in the same wall are prohibited. A minimum 600 mm (24 inch) center-to-center lateral spacing shall be maintained between boxes.

F. Flush-mounted wall or ceiling boxes shall be installed with raised covers so that the front face of raised cover is flush with the wall. Surface-mounted wall or ceiling boxes shall be installed with surface-style flat or raised covers.

G. Minimum size of outlet boxes for ground fault circuit interrupter (GFCI) receptacles is 100 mm (4 inches) square x 55 mm (2.125 inches) deep, with device covers for the wall material and thickness involved.

H. Stencil or install phenolic nameplates on covers of the boxes identified on riser diagrams; for example "ELECTRICAL PB No. 1."

I. On all branch circuit junction box covers, identify the circuits with black marker.

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SECTION 26 05 41
UNDERGROUND ELECTRICAL CONSTRUCTION

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, installation, and connection of underground ducts and raceways, and precast manholes and pullboxes to form a complete underground electrical raceway system.

B. The terms "duct" and "conduit" are used interchangeably in this section.

1.2 RELATED WORK

A. Section 07 92 00, JOINT SEALANTS: Sealing of conduit penetrations.

B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.

C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.

D. Section 31 20 00, EARTH MOVING Trenching, backfill, and compaction.

1.3 QUALITY ASSURANCE

A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

B. Coordinate layout and installation of ducts, manholes, and pullboxes with final arrangement of other utilities, site grading, and surface features.

1.4 SUBMITTALS

A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:

1. Shop Drawings:

a. Submit sufficient information to demonstrate compliance with drawings and specifications.

b. Submit information on manholes, pullboxes, ducts, and hardware. Submit manhole plan and elevation drawings, showing openings, pulling irons, cable supports, cover, ladder, sump, and other accessories.

c. Proposed deviations from the drawings shall be clearly marked on the submittals. If it is necessary to locate manholes, pullboxes,

or duct banks at locations other than shown on the drawings, show the proposed locations accurately on scaled site drawings, and submit to the COR for approval prior to construction.

2. Certifications: Two weeks prior to the final inspection, submit the following.
   a. Certification by the manufacturer that the materials conform to the requirements of the drawings and specifications.
   b. Certification by the Contractor that the materials have been properly installed, connected, and tested.

1.5 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

B. American Concrete Institute (ACI):
Building Code Requirements for Structural Concrete
318-19/318M-19.....Building Code Requirements for Structural Concrete & Commentary
MNL-66-20.....ACI Detailing Manual

C. American National Standards Institute (ANSI):
77-17.....Underground Enclosure Integrity

D. American Society for Testing and Materials (ASTM):
C478/C478M-20.....Standard Specification for Precast Reinforced Concrete Manhole Sections
C858-19.....Underground Precast Concrete Utility Structures
C990/C990M-09.....Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants.

E. National Electrical Manufacturers Association (NEMA):
TC 2-20.....Electrical Polyvinyl Chloride (PVC) Conduit
TC 3-21.....Polyvinyl Chloride (PVC) Fittings for Use With Rigid PVC Conduit And Tubing
TC 6 & 8-20.....Polyvinyl Chloride (PVC) Plastic Utilities Duct For Underground Installations
TC 9-20.....Fittings For Polyvinyl Chloride (PVC) Plastic Utilities Duct For Underground Installation

F. National Fire Protection Association (NFPA):
70-23.....National Electrical Code (NEC)

70E-21.....National Electrical Safety Code

G. Underwriters Laboratories, Inc. (UL):

6-07.....Electrical Rigid Metal Conduit-Steel

467-13.....Grounding and Bonding Equipment

651-11.....Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings

651A-11.....Schedule 40 and 80 High Density Polyethylene (HDPE) Conduit

PART 2 - PRODUCTS

2.1 PRE-CAST CONCRETE MANHOLES AND HARDWARE

A. Structure: Factory-fabricated, reinforced-concrete, monolithically-poured walls and bottom. Frame and cover shall form top of manhole.

B. Cable Supports:

1. Cable stanchions shall be hot-rolled, heavy duty, hot-dipped galvanized "T" section steel, 56 mm (2.25 inches) x 6 mm (0.25 inch) in size, and punched with 14 holes on 38 mm (1.5 inches) centers for attaching cable arms.
2. Cable arms shall be 5 mm (0.1875 inch) gauge, hot-rolled, hot-dipped galvanized sheet steel, pressed to channel shape. Arms shall be approximately 63 mm (2.5 inches) wide x 350 mm (14 inches) long.
3. Insulators for cable supports shall be porcelain, and shall be saddle type or type that completely encircles the cable.
4. Equip each cable stanchion with one spare cable arm, with three spare insulators for future use.

C. Ladder: Fiberglass with 400 mm (16 inches) rung spacing. Provide securely-mounted ladder for every manhole over 1.2 M (4 feet) deep.

D. Ground Rod Sleeve: Provide a 75 mm (3 inches) PVC sleeve in manhole floors so that a driven ground rod may be installed.

E. Sump: Provide 305 mm x 305 mm (12 inches x 12 inches) covered sump frame and grated cover.

2.2 PULLBOXES

A. General: Size as indicated on the drawings. Provide pullboxes with weatherproof, non-skid covers with recessed hook eyes, secured with corrosion- and tamper-resistant hardware. Cover material shall be identical to pullbox material. Covers shall have molded lettering, ELECTRIC, as applicable. Pullboxes shall comply with the requirements of ANSI 77 Tier 15 loading. Provide pulling irons, 22 mm (0.875 inch) diameter galvanized steel bar with exposed triangular-shaped opening.

B. Polymer Concrete Pullboxes: Shall be molded of sand, aggregate, and polymer resin, and reinforced with steel, fiberglass, or both. Pullbox shall have open bottom.

2.3 DUCTS

A. Number and sizes shall be as shown on the drawings.

B. Ducts (concrete-encased):

1. Plastic Duct:

a. UL 651 and 651A Schedule 40 PVC conduit.

b. Duct shall be suitable for use with 90˚ C (194˚ F) rated conductors.

2. Conduit Spacers: Prefabricated plastic.

C. Ducts (direct-burial):

1. Plastic duct:

a. Schedule 80 PVC or HDPE conduit.

b. Duct shall be suitable for use with 75˚ C (167˚ F) rated conductors.

2. Rigid metal conduit: UL 6 and NEMA RN1 galvanized rigid metal, half-lap wrapped with 10 mil PVC tape.

2.4 GROUNDING

A. Ground Rods and Ground Wire: Per Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

2.5 WARNING TAPE

A. 4-mil polyethylene 75 mm (3 inches) wide detectable tape, red with black letters, imprinted with “CAUTION - BURIED ELECTRIC CABLE BELOW” or similar.

2.6 PULL ROPE FOR SPARE DUCTS

A. Plastic with 890 N (200 lb) minimum tensile strength.

PART 3 - EXECUTION

3.1 MANHOLE AND PULLBOX INSTALLATION

A. Assembly and installation shall be per the requirements of the manufacturer.

1. Install manholes and pullboxes level and plumb.

2. Units shall be installed on a 300 mm (12 inches) thick level bed of 90% compacted granular fill, well-graded from the 25 mm (1 inch) sieve to the No. 4 sieve. Granular fill shall be compacted with a minimum of four passes with a plate compactor.

B. Access: Ensure the top of frames and covers are flush with finished grade.

C. Grounding in Manholes:
   1. Ground Rods in Manholes: Drive a ground rod into the earth, through the floor sleeve, after the manhole is set in place. Fill the sleeve with sealant to make a watertight seal. Rods shall protrude approximately 100 mm (4 inches) above the manhole floor.
   2. Install a No. 3/0 AWG bare copper ring grounding conductor around the inside perimeter of the manhole and anchor to the walls with metallic cable clips.
   3. Connect the ring grounding conductor to the ground rod by an exothermic welding process.
   4. Bond the ring grounding conductor to the duct bank equipment grounding conductors, the exposed non-current carrying metal parts of racks, sump covers, and like items in the manholes with a minimum No. 6 AWG bare copper jumper using an exothermic welding process.

3.2 TRENCHING

A. Refer to Section 31 20 00, EARTH MOVING for trenching, backfilling, and compaction.
B. Before performing trenching work at existing facilities, a Ground Penetrating Radar Survey shall be carefully performed by a certified technician to reveal all existing underground ducts, conduits, cables, and other utility systems.
C. Work with extreme care near existing ducts, conduits, and other utilities to avoid damaging them.
D. Cut the trenches neatly and uniformly.
E. For Concrete-Encased Ducts:
   1. After excavation of the trench, stakes shall be driven in the bottom of the trench at 1.2 M (4 feet) intervals to establish the grade and route of the duct bank.
   2. Pitch the trenches uniformly toward manholes or both ways from high points between manholes for the required duct line drainage. Avoid pitching the ducts toward buildings wherever possible.
   3. The walls of the trench may be used to form the side walls of the duct bank, provided that the soil is self-supporting and that the concrete envelope can be poured without soil inclusions. Forms are required where the soil is not self-supporting.

4. After the concrete-encased duct has sufficiently cured, the trench shall be backfilled to grade with earth, and appropriate warning tape installed.

F. Individual conduits to be installed under existing paved areas and roads that cannot be disturbed shall be jacked into place using rigid metal conduit, or bored using plastic utilities duct or PVC conduit, as approved by the COR.

3.3 DUCT INSTALLATION

A. General Requirements:

1. Ducts shall be in accordance with the NEC, as shown on the drawings, and as specified.
2. Join and terminate ducts with fittings recommended by the manufacturer.
3. Slope ducts to drain towards manholes and pullboxes, and away from building and equipment entrances. Pitch not less than 100 mm (4 inches) in 30 M (100 feet).
4. Underground conduit stub-ups and sweeps to equipment inside of buildings shall be galvanized rigid metal conduit half-lap wrapped with PVC tape, and shall extend a minimum of 1.5 M (5 feet) outside the building foundation. Tops of conduits below building slab shall be minimum 610 mm (24 inches) below bottom of slab.
5. Stub-ups and sweeps to equipment mounted on outdoor concrete slabs shall be galvanized rigid metal conduit half-lap wrapped with PVC tape, and shall extend a minimum of 1.5 M (5 feet) away from the edge of slab.
6. Install insulated grounding bushings on the conduit terminations.
7. Radius for sweeps shall be sufficient to accomplish pulls without damage. Minimum radius shall be six times conduit diameter.
8. All multiple conduit runs shall have conduit spacers. Spacers shall securely support and maintain uniform spacing of the duct assembly a minimum of 75 mm (3 inches) above the bottom of the trench during the concrete pour. Spacer spacing shall not exceed 1.5 M (5 feet). Secure spacers to ducts and earth to prevent floating during concrete pour. Provide nonferrous tie wires to prevent displacement of the ducts during concrete pour. Tie wires shall not act as substitute for spacers.
9. Duct lines shall be installed no less than 300 mm (12 inches) from other utility systems, such as water, sewer, chilled water.

10. Clearances between individual ducts:
    a. For similar services, not less than 75 mm (3 inches).
    b. For power and signal services, not less than 150 mm (6 inches).
11. Duct lines shall terminate at window openings in manhole walls as shown on the drawings. All ducts shall be fitted with end bells.
12. Couple the ducts with proper couplings. Stagger couplings in rows and layers to ensure maximum strength and rigidity of the duct bank.
13. Keep ducts clean of earth, sand, or gravel, and seal with tapered plugs upon completion of each portion of the work.
14. Spare Ducts: Where spare ducts are shown, they shall have a nylon pull rope installed. They shall be capped at each end and labeled as to location of the other end.
15. Duct Identification: Place continuous strip of warning tape approximately 300 mm (12 inches) above ducts before backfilling trenches. Warning tape shall be preprinted with proper identification.
16. Duct Sealing: Seal ducts, including spare ducts, at building entrances and at outdoor terminations for equipment, with a suitable non-hardening compound to prevent the entrance of foreign objects and material, moisture, and gases.
17. Use plastic ties to secure cables to insulators on cable arms. Use minimum two ties per cable per insulator.

B. Concrete-Encased Ducts:
    1. Install concrete-encased ducts for medium-voltage systems, low-voltage systems, and signal systems, unless otherwise shown on the drawings.
    2. Duct banks shall be single or multiple duct assemblies encased in concrete. Ducts shall be uniform in size and material throughout the installation.
    3. Tops of concrete-encased ducts shall be:
        a. Not less than 600 mm (24 inches) and not less than shown on the drawings, below finished grade.
        b. Not less than 750 mm (30 inches) and not less than shown on the drawings, below roads and other paved surfaces.
        c. Additional burial depth shall be required in order to accomplish NEC-required minimum bend radius of ducts.
        d. Conduits crossing under grade slab construction joints shall be installed a minimum of 1.2 M (4 feet) below slab.

4. Extend the concrete envelope encasing the ducts not less than 75 mm (3 inches) beyond the outside walls of the outer ducts.
5. Within 3 M (10 feet} of building and manhole wall penetrations, install reinforcing steel bars at the top and bottom of each concrete envelope to provide protection against vertical shearing.
6. Install reinforcing steel bars at the top and bottom of each concrete envelope of all ducts underneath roadways and parking areas.
7. Where new ducts and concrete envelopes are to be joined to existing manholes, pullboxes, ducts, and concrete envelopes, make the joints with the proper fittings and fabricate the concrete envelopes to ensure smooth durable transitions.
8. Duct joints in concrete may be placed side by side horizontally, but shall be staggered at least 150 mm (6 inches) vertically.
9. Pour each run of concrete envelope between manholes or other terminations in one continuous pour. If more than one pour is necessary, terminate each pour in a vertical plane and install 19 mm (0.75 inch) reinforcing rod dowels extending 450 mm (18 inches) into concrete on both sides of joint near corners of envelope.
10. Pour concrete so that open spaces are uniformly filled. Do not agitate with power equipment unless approved by COR.

C. Direct-Burial Ducts:
1. Install direct-burial ducts only where shown on the drawings. Provide direct-burial ducts only for low-voltage power and lighting branch circuits.
2. Tops of ducts shall be:
   a. Not less than 600 mm (24 inches) and not less than shown on the drawings, below finished grade.
   b. Not less than 750 mm (30 inches) and not less than shown on the drawings, below roads and other paved surfaces.
   c. Additional burial depth shall be required in order to accomplish NEC-required minimum bend radius of ducts.
3. Do not kink the ducts. Compaction shall not deform the ducts.

D. Connections to Manholes: Ducts connecting to manholes shall be flared to have an enlarged cross-section to provide additional shear strength. Dimensions of the flared cross-section shall be larger than the corresponding manhole opening dimensions by no less than 300 mm (12 inches) in each direction. Perimeter of the duct bank opening in the

manhole shall be flared toward the inside or keyed to provide a positive interlock between the duct and the wall of the manhole. Use vibrators when this portion of the encasement is poured to ensure a seal between the envelope and the wall of the structure.

E. Connections to Existing Manholes: For duct connections to existing manholes, break the structure wall out to the dimensions required and preserve the steel in the structure wall. Cut steel and extend into the duct bank envelope. Chip the perimeter surface of the duct bank opening to form a key or flared surface, providing a positive connection with the duct bank envelope.

F. Connections to Existing Ducts: Where connections to existing ducts are indicated, excavate around the ducts as necessary. Cut off the ducts and remove loose concrete from inside before installing new ducts. Provide a reinforced-concrete collar, poured monolithically with the new ducts, to take the shear at the joint of the duct banks.

G. Partially-Completed Ducts: During construction, wherever a construction joint is necessary in a duct bank, prevent debris such as mud and dirt from entering ducts by providing suitable plugs. Fit concrete envelope of a partially completed ducts with reinforcing steel extending a minimum of 600 mm (2 feet) back into the envelope and a minimum of 600 mm (2 feet) beyond the end of the envelope. Provide one No. 4 bar in each corner, 75 mm (3 inches) from the edge of the envelope. Secure corner bars with two No. 3 ties, spaced approximately 300 mm (12 inches) apart. Restrain reinforcing assembly from moving during pouring of concrete.

3.4 ACCEPTANCE CHECKS AND TESTS

A. Duct Testing and Cleaning:

1. Upon completion of the duct installation, a standard flexible mandrel shall be pulled through each duct to loosen particles of earth, sand, or foreign material left in the duct, and to test for out-of-round conditions.
2. The mandrel shall be not less than 300 mm (12 inches) long, and shall have a diameter not less than 13 mm (0.5 inch) less than the inside diameter of the duct. A brush with stiff bristles shall then be pulled through each duct to remove the loosened particles. The diameter of the brush shall be the same as, or slightly larger than, the diameter of the duct.

3. If testing reveals obstructions or out-of-round conditions, the Contractor shall replace affected section(s) of duct and retest to the satisfaction of the COR.
4. Mandrel pulls shall be witnessed by the COR.

---END---

SECTION 26 05 73
OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the overcurrent protective device coordination study, related calculations and analysis, indicated as the study in this section.

B. A short-circuit and selective coordination study, and arc flash calculations and analysis shall be prepared for the electrical overcurrent devices to be installed under this project.

C. The study shall present a well-coordinated time-current analysis of each overcurrent protective device from the individual device up to the utility source and the on-site generator sources.

1.2 RELATED WORK

A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements that are common to more than one section of Division 26.

B. Section 26 13 16, MEDIUM-VOLTAGE FUSIBLE INTERRUPTER SWITCHES: Medium-voltage fusible interrupter switches.

C. Section 26 24 13, DISTRIBUTION SWITCHBOARDS: Low-voltage distribution switchboards.

D. Section 26 24 16, PANELBOARDS: Low-voltage panelboards.

E. Section 26 32 13, ENGINE GENERATORS: Engine generators.

F. Section 26 36 23, AUTOMATIC TRANSFER SWITCHES: Automatic transfer switches.

1.3 QUALITY ASSURANCE

A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

B. The study shall be prepared by the equipment manufacturer, and performed by the equipment manufacturer’s licensed electrical engineer.

1.4 SUBMITTALS

A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:

1. Product data on the software program to be used for the study. Software shall be in mainstream use in the industry, shall provide device settings and ratings, and shall show selective coordination by time-current drawings.
2. Complete study as described in paragraph 1.6. Submittal of the study shall be well-coordinated with submittals of the shop drawings for equipment in related specification sections.
3. Certifications: Two weeks prior to final inspection, submit the following.
   a. Certification by the Contractor that the overcurrent protective devices have been set in accordance with the approved study.

1.5 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

B. Institute of Electrical and Electronics Engineers (IEEE):

241-90.....Recommended Practice Electrical Systems in Commercial Buildings

242-01.....Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems

399-97.....Recommended Practice for Industrial and Commercial Power Systems Analysis

1584-18.....Performing Arc-Flash Hazards Calculations

C. National Fire Protection Association (NFPA):

70-23.....National Electrical Code (NEC)

70E-21.....Standard for Electrical Safety in the Workplace

99-21.....Health Care Facilities Code

1.6 STUDY REQUIREMENTS

A. The study shall be in accordance with IEEE and NFPA standards.

B. The study shall include one line diagram, short-circuit and ground fault analysis, protective coordination plots for all overcurrent protective devices, and arc flash calculations and analysis.

C. One Line Diagram:
   1. Show all electrical equipment and wiring to be protected by the overcurrent devices.

2. Show the following specific information:
   a. Calculated fault impedance, X/R ratios, and short-circuit values at each feeder and branch circuit bus.
   b. Relay, circuit breaker, and fuse ratings.
   c. Generator kW/kVA and transformer kVA and voltage ratings, percent impedance, X/R ratios, and wiring connections.
   d. Voltage at each bus.
   e. Identification of each bus, matching the identification on the drawings.
   f. Conduit, conductor, and busway material, size, length, and X/R ratios.

D. Short-Circuit Study:
   1. The study shall be performed using computer software designed for this purpose. Pertinent data and the rationale employed in developing the calculations shall be described in the introductory remarks of the study.
   2. Calculate the fault impedance to determine the available short-circuit and ground fault currents at each bus. Incorporate applicable motor and/or generator contribution in determining the momentary and interrupting ratings of the overcurrent protective devices.
   3. Present the results of the short-circuit study in a table. Include the following:
      a. Device identification.
      b. Operating voltage.
      c. Overcurrent protective device type and rating.
      d. Calculated short-circuit current.

E. Coordination Study:
   1. Prepare the coordination curves to determine the required settings of overcurrent protective devices to demonstrate selective coordination. Graphically illustrate on log-log paper that adequate time separation exists between devices, including the utility company upstream device if applicable. Plot the specific time-current characteristics of each overcurrent protective device in such a manner that all devices are clearly depicted.
   2. The following specific information shall also be shown on the coordination curves:

a. Device identification.
b. Potential transformer and current transformer ratios.
c. Three-phase and single-phase ANSI damage points or curves for each cable, transformer, or generator.
d. Applicable circuit breaker or protective relay characteristic curves.
e. No-damage, melting, and clearing curves for fuses.
f. Transformer in-rush points.

3. Develop a table to summarize the settings selected for the overcurrent protective devices. Include the following in the table:
a. Device identification.
b. Protective relay or circuit breaker potential and current transformer ratios, sensor rating, and available and suggested pickup and delay settings for each available trip characteristic.
c. Fuse rating and type.

F. Arc Flash Calculations and Analysis:
1. Arc flash warning labels shall comply with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
2. Arc flash calculations shall be based on actual over-current protective device clearing time. Maximum clearing time shall be in accordance with IEEE 1584.
3. Arc flash analysis shall be based on the lowest clearing time setting of the over-current protective device to minimize the incident energy level without compromising selective coordination.
4. Arc flash boundary and available arc flash incident energy at the corresponding working distance shall be calculated for all electrical power distribution equipment specified in the project, and as shown on the drawings.
5. Required arc-rated clothing and other PPE shall be selected and specified in accordance with NFPA 70E.

1.7 ANALYSIS

A. Analyze the short-circuit calculations, and highlight any equipment determined to be underrated as specified. Propose solutions to effectively protect the underrated equipment.

1.8 ADJUSTMENTS, SETTINGS, AND MODIFICATIONS

A. Final field settings and minor modifications of the overcurrent protective devices shall be made to conform with the study, without additional cost to the Government.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION (NOT USED)

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SECTION 26 08 00

COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. The requirements of this Section apply to all sections of Division 26.

B. This project will have selected building systems commissioned. The complete list of equipment and systems to be commissioned is specified in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS. The commissioning process, which the Contractor is responsible to execute, is defined in Section 01 91 00 GENERAL COMMISSIONING REQUIRMENTS. A Commissioning Agent (CxA) appointed by the VA will manage the commissioning process.

1.2 RELATED WORK

A. Section 01 00 00 GENERAL REQUIREMENTS.

B. Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS.

C. Section 01 33 23 SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

1.3 SUMMARY

A. This Section includes requirements for commissioning the Facility electrical systems, related subsystems and related equipment. This Section supplements the general requirements specified in Section 01 91 00 General Commissioning Requirements.

B. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for more details regarding processes and procedures as well as roles and responsibilities for all Commissioning Team members.

1.4 DEFINITIONS

A. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for definitions.

1.5 COMMISSIONED SYSTEMS

A. Commissioning of a system or systems specified in Division 26 is part of the construction process. Documentation and testing of these systems, as well as training of the VA’s Operation and Maintenance personnel in accordance with the requirements of Section 01 91 00 and of Division 26, is required in cooperation with the VA and the Commissioning Agent.

B. The Facility electrical systems commissioning will include the systems listed in Section 01 91 00 General Commissioning Requirements:

1.6 SUBMITTALS

A. The commissioning process requires review of selected Submittals that pertain to the systems to be commissioned. The Commissioning Agent will provide a list of submittals that will be reviewed by the Commissioning Agent. This list will be reviewed and approved by the VA prior to forwarding to the Contractor. Refer to Section 01 33 23 SHOP DRAWINGS, PRODUCT DATA, and SAMPLES for further details.

B. The commissioning process requires Submittal review simultaneously with engineering review. Specific submittal requirements related to the commissioning process are specified in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 CONSTRUCTION INSPECTIONS

A. Commissioning of Electrical systems will require inspection of individual elements of the electrical systems construction throughout the construction period. The Contractor shall coordinate with the Commissioning Agent in accordance with Section 01 91 00 and the Commissioning plan to schedule electrical systems inspections as required to support the Commissioning Process.

3.2 PRE-FUNCTIONAL CHECKLISTS

A. The Contractor shall complete Pre-Functional Checklists to verify systems, subsystems, and equipment installation is complete and systems are ready for Systems Functional Performance Testing. The Commissioning Agent will prepare Pre-Functional Checklists to be used to document equipment installation. The Contractor shall complete the checklists. Completed checklists shall be submitted to the VA and to the Commissioning Agent for review. The Commissioning Agent may spot check a sample of completed checklists. If the Commissioning Agent determines that the information provided on the checklist is not accurate, the Commissioning Agent will return the marked-up checklist to the Contractor for correction and resubmission. If the Commissioning Agent determines that a significant number of completed checklists for similar equipment are not accurate, the Commissioning Agent will select a broader sample of checklists for review. If the Commissioning Agent determines that a significant number of the broader sample of checklists is also inaccurate, all the checklists for the type of equipment will be returned to the Contractor for correction and

resubmission. Refer to SECTION 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for submittal requirements for Pre-Functional Checklists, Equipment Startup Reports, and other commissioning documents.

3.3 CONTRACTORS TESTS

A. Contractor tests as required by other sections of Division 26 shall be scheduled and documented in accordance with Section 01 00 00 GENERAL REQUIREMENTS. All testing shall be incorporated into the project schedule. Contractor shall provide no less than 7 calendar days' notice of testing. The Commissioning Agent will witness selected Contractor tests at the sole discretion of the Commissioning Agent. Contractor tests shall be completed prior to scheduling Systems Functional Performance Testing.

3.4 SYSTEMS FUNCTIONAL PERFORMANCE TESTING

A. The Commissioning Process includes Systems Functional Performance Testing that is intended to test systems functional performance under steady state conditions, to test system reaction to changes in operating conditions, and system performance under emergency conditions. The Commissioning Agent will prepare detailed Systems Functional Performance Test procedures for review and approval by the COR. The Contractor shall review and comment on the tests prior to approval. The Contractor shall provide the required labor, materials, and test equipment identified in the test procedure to perform the tests. The Commissioning Agent will witness and document the testing. The Contractor shall sign the test reports to verify tests were performed. See Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS, for additional details.

3.5 TRAINING OF VA PERSONNEL

A. Training of the VA operation and maintenance personnel is required in cooperation with the COR and Commissioning Agent. Provide competent, factory authorized personnel to provide instruction to operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. Contractor shall submit training agendas and trainer resumes in accordance with the requirements of Section 01 91 00. The instruction shall be scheduled in coordination with the VA COR after submission and approval of formal training plans. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS and Division 26 Sections for additional Contractor training requirements.

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SECTION 26 09 23
LIGHTING CONTROLS

PART 1 - GENERAL

1.1 DESCRIPTION

This section specifies the furnishing, installation and connection of the lighting controls.

1.2 RELATED WORK

A. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC: Interface of lighting controls with HVAC control systems.

B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General requirements that are common to more than one section of Division 26.

C. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW): Cables and wiring.

D. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path to ground for possible ground fault currents.

E. Section 26 24 16, PANELBOARDS: Panelboard enclosure and interior bussing used for lighting control panels.

F. Section 26 27 26, WIRING DEVICES: Wiring devices used for control of the lighting systems.

G. Section 26 51 00, INTERIOR LIGHTING: Luminaire ballast and drivers used in control of lighting systems.

1.3 QUALITY ASSURANCE

A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:

1. Shop Drawings:
   a. Submit the following information for each type of lighting controls.
   b. Material and construction details.
   c. Physical dimensions and description.
   d. Wiring schematic and connection diagram.
   e. Installation details.

2. Manuals:
   a. Submit, simultaneously with the shop drawings, complete maintenance and operating manuals, including technical data sheets, wiring diagrams, and information for ordering replacement parts.
   b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
3. Certifications: Two weeks prior to final inspection, submit the following.
   a. Certification by the Contractor that the lighting control systems have been properly installed and tested.

1.5 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

B. National Electrical Manufacturer's Association (NEMA):

C136.10-17.....American National Standard for Roadway and Area Lighting Equipment—Locking-Type Photocontrol Devices and Mating Receptacles—Physical and Electrical Interchangeability and Testing

ICS-1-00(R2015).....Standard for Industrial Control and Systems General Requirements

ICS-2-00(R2020).....Standard for Industrial Control and Systems Controllers, Contractors, and Overload Relays Rated 600 Volts

ICS-6-93(R2016).....Standard for Industrial Controls and Systems Enclosures

C. National Fire Protection Association (NFPA):

70-23.....National Electrical Code (NEC)

D. Underwriters Laboratories, Inc. (UL):

20-18.....Standard for General-Use Snap Switches

98-16.....Enclosed and Dead-Front Switches

773-16.....Standard for Plug-In Locking Type Photocontrols for Use with Area Lighting

773A-16.....Nonindustrial Photoelectric Switches for Lighting Control

916-15.....Standard for Energy Management Equipment

917-06.....Clock Operated Switches

924-16.....Emergency Lighting and Power Equipment

PART 2 - PRODUCTS

2.1 OUTDOOR PHOTOELECTRIC SWITCHES

A. Solid state, with SPST dry contacts rated for 1800 VA tungsten or 1000 VA inductive, complying with UL 773A.

1. Light-Level Monitoring Range: 16.14 to 108 lx (1.5 to 10 fc), with adjustable turn-on and turn-off levels.
2. Time Delay: 15-second minimum.
3. Surge Protection: Metal-oxide varistor.
4. Mounting: Twist lock, with base-and-stem mounting or stem-and-swivel mounting accessories as required.

2.2 INDOOR OCCUPANCY SENSORS

A. Wall- or ceiling-mounting, solid-state units with a power supply and relay unit, suitable for the environmental conditions in which installed.

1. Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied; with a 1 to 15 minute adjustable time delay for turning lights off.
2. Sensor Output: Contacts rated to operate the connected relay. Sensor shall be powered from the relay unit.
3. Relay Unit: Dry contacts rated for 20A ballast load at 120 volt and 277 volt, for 13A tungsten at 120 volt, and for 1 hp at 120 volt.
4. Mounting:
   a. Sensor: Suitable for mounting in any position on a standard outlet box.
   b. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
5. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.
6. Bypass Switch: Override the on function in case of sensor failure.
7. Manual/automatic selector switch.
8. Automatic Light-Level Sensor: Adjustable from 21.5 to 2152 lx (2 to 200 fc); keep lighting off when selected lighting level is present.
9. Faceplate for Wall-Switch Replacement Type: Refer to wall plate material and color requirements for toggle switches, as specified in Section 26 27 26, WIRING DEVICES.

B. Dual-technology Type: Ceiling mounting; combination PIR and ultrasonic detection methods, field-selectable.
   1. Sensitivity Adjustment: Separate for each sensing technology.
   2. Detector Sensitivity: Detect occurrences of 150 mm (6-inch) minimum movement of any portion of a human body that presents a target of not less than 232 sq. cm (36 sq. in), and detect a person of average size and weight moving not less than 305 mm (12 inches) in either a horizontal or a vertical manner at an approximate speed of 305 mm/s (12 inches/s).

C. Detection Coverage: Shall be sufficient to provide coverage as required by sensor locations shown on drawing.

2.3 INDOOR VACANCY SENSOR SWITCH

A. Wall mounting, solid-state units with integral sensor and switch.
   1. Operation: Manually turn lights on with switch and sensor detects vacancy to turn lights off.
   2. Switch Rating: 120/277 volt, 1200 watts at 277 volt, 800 watts at 120 volt unit.
   3. Mounting:
      a. Sensor: Suitable for mounting in a standard switch box.
      b. Time-Delay and Sensitivity Adjustments: Integral with switch and accessible for reprogramming without removing switch.
   4. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.
   5. Switch: Manual operation to turn lights on and override lights off.
   6. Faceplate: Refer to wall plate material and color requirements for toggle switches, as specified in Section 26 27 26, WIRING DEVICES.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation shall be in accordance with the NEC, manufacturer's instructions, as shown on the drawings, and as specified.

B. Aim outdoor photoelectric sensor according to manufacturer's recommendations. Set adjustable window slide for 1 footcandle turn-on.

C. Aiming for wall-mounted and ceiling-mounted motion sensor switches shall be per manufacturer’s recommendations.

D. Set occupancy sensor "on" duration to 15 minutes.

E. Locate photoelectric sensors as indicated and in accordance with the manufacturer's recommendations. Adjust sensor for the available light level at the typical work plane for that area.

F. Label time switches and contactors with a unique designation.

G. Program lighting control panels per schedule on drawings.

3.2 ACCEPTANCE CHECKS AND TESTS

A. Perform in accordance with the manufacturer's recommendations.

B. Upon completion of installation, conduct an operating test to show that equipment operates in accordance with requirements of this section.

C. Test for full range of dimming ballast and dimming controls capability. Observe for visually detectable flicker over full dimming range.

D. Test occupancy sensors for proper operation. Observe for light control over entire area being covered.

3.3 FOLLOW-UP VERIFICATION

Upon completion of acceptance checks and tests, the Contractor shall show by demonstration in service that the lighting control devices are in good operating condition and properly performing the intended function in the presence of COR.

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SECTION 26 12 19
PAD-MOUNTED, LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, installation, connection, and testing of the pad-mounted, liquid-filled, medium-voltage transformers, indicated as transformers in this section.

1.2 RELATED WORK

A. Section 03 30 00, CAST-IN-PLACE CONCRETE: Requirements for concrete equipment pads.

B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.

C. Section 26 05 13, MEDIUM-VOLTAGE CABLES: Medium-voltage cables.

D. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path to ground for possible ground currents.

E. Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION: Manholes, pull-boxes, and ducts for underground raceway systems.

F. Section 26 05 73, OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY: Short circuit and coordination study, and requirements for a coordinated electrical system.

1.3 QUALITY ASSURANCE

A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 FACTORY TESTS

A. Factory Tests shall be required.

B. Factory Tests shall be in accordance with Paragraph, MANUFACTURED PRODUCTS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirement:

1. Transformers shall be thoroughly tested at the factory to ensure that there are no electrical or mechanical defects. Tests shall be conducted as per IEEE Standards. Factory tests shall be certified. The following tests shall be performed:
   a. Perform insulation-resistance tests, winding-to-winding and each winding-to-ground.
   b. Perform turns-ratio tests at all tap positions.

1.5 SUBMITTALS

A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:

1. Shop Drawings:
   a. Submit sufficient information to demonstrate compliance with drawings and specifications.
   b. Include electrical ratings, nameplate data, impedance, outline drawing with dimensions and front, top, and side views, weight, mounting details, decibel rating, termination information, temperature rise, no-load and full-load losses, regulation, overcurrent protection, connection diagrams, and accessories.
   c. Complete nameplate data, including manufacturer’s name and catalog number.

2. Manuals:
   a. When submitting the shop drawings, submit companion copies of complete maintenance and operating manuals, including technical data sheets, wiring diagrams, and information for ordering replacement parts.
      1) Identify terminals on wiring diagrams to facilitate installation, maintenance, and operation.
      2) Indicate on wiring diagrams the internal wiring for each piece of equipment and interconnections between the pieces of equipment.
      3) Approvals will be based on complete submissions of manuals, together with shop drawings.
   b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
      1) Update the manual to include any information necessitated by shop drawing approval.
      2) Show all terminal identification.
      3) Include information for testing, repair, troubleshooting, assembly, disassembly, and recommended maintenance intervals.
      4) Provide a replacement parts list with current prices. Include a list of recommended spare parts, tools, and instruments for testing and maintenance purposes.

B. Certifications:

1. Two weeks prior to the final inspection, submit the following certifications.
   a. Certification by the manufacturer that the transformers conform to the requirements of the drawings and specifications.
   b. Certification by the Contractor that the transformers have been properly installed, connected, and tested.

1.6 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

B. American Society for Testing and Materials (ASTM):

D3487-16.....Standard Specification for Mineral Insulating Oil Used in Electrical Apparatus

C. Institute of Electrical and Electronic Engineers (IEEE):

48-20.....Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5kV Through 765kV or Extruded Insulation Rated 2.5kV Through 500kV

386-16.....Separable Insulated Connector Systems for Power Distribution Systems Above 600 V

592-18.....Insulation Shields on Medium-Voltage (15 kV - 35 kV) Cable Joints and Separable Connectors

C2-17.....National Electrical Safety Code

C37.42-16.....Specifications for High-Voltage (>1000 V) Fuses and Accessories

C57.12.00-21.....Liquid-Immersed Distribution, Power and Regulating Transformers

C57.12.10-17.....Liquid-Immersed Power Transformers

C57.12.25-90.....Pad-Mounted, Compartmental-Type, Self-Cooled, Single-Phase Distribution-Transformers with Separable Insulated High Voltage Connectors; High Voltage, 34500 Grd Y/19920 Volts and Below; Low-Voltage 240/120 Volts; 167 kVA and Smaller Requirements

C57.12.28-14.....Pad-Mounted Equipment - Enclosure Integrity

C57.12.29-14.....Pad-Mounted Equipment – Enclosure Integrity for Coastal Environments

C57.12.34-15.....Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers, 5 MVA and Smaller; High Voltage, 34.5 kV Nominal System Voltage and Below; Low Voltage, 15kV Nominal System Voltage and Below

C57.12.90-21.....Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers

C62.11-20.....Metal-Oxide Surge Arresters for AC Power Circuits

D. International Code Council (ICC):

IBC-21.....International Building Code

E. National Electrical Manufacturers Association (NEMA):

TR 1-13(R2019).....Transformers, Regulators, and Reactors

F. National Fire Protection Association (NFPA):

70-23.....National Electrical Code (NEC)

G. Underwriters Laboratories Inc. (UL):

467-13.....Grounding and Bonding Equipment

H. United States Department of Energy (DOE):

10 CFR Part 431.....Energy Efficiency Program for Certain Commercial and Industrial Equipment

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Transformers shall be in accordance with ASTM, IEEE, NFPA, UL, as shown on the drawings, and as specified herein. Each transformer shall be assembled as an integral unit by a single manufacturer.

B. Transformers shall be complete, outdoor type, continuous duty, integral assembly, grounded, tamper-resistant, and with liquid-immersed windings.

C. Ratings shall not be less than shown on the drawings.

D. Completely fabricate transformers at the factory so that only the external cable connections are required at the project site.

E. Thoroughly clean, phosphatize, and finish all the metal surfaces at the factory with a rust-resistant primer and dark green enamel finish coat, except where a different color is specified in Section 09 06 00, SCHEDULE FOR FINISHES. All surfaces of the transformer that will be in

contact with the concrete pad shall be treated with corrosion-resistant compounds and epoxy resin or a rubberized sealing compound.

2.2 COMPARTMENTS

A. Construction:

1. Enclosures shall be weatherproof and in accordance with IEEE C57.12.28.
2. The medium- and low-voltage compartments shall be separated with a steel barrier that extends the full height and depth of the compartments.
3. The compartments shall be constructed of sheet steel (gauge to meet ANSI requirements) with bracing and with reinforcing gussets using jig welds to assure rectangular rigidity.
4. All bolts, nuts, and washers shall be zinc-plated steel.
5. Sufficient space shall be provided for equipment, cabling, and terminations within the compartments.
6. Affix transformer nameplate permanently within the low-voltage compartment. Voltage and kVA rating, connection configuration, impedance, date of manufacture, and serial number shall be shown on the nameplate.

B. Doors:

1. Provide a separate door for each compartment with provisions for a single padlock to secure all doors. Provide each compartment door with open-position doorstops and corrosion-resistant tamperproof hinges welded in place. The medium-voltage compartment door shall be mechanically prevented from opening unless the low-voltage compartment door is open.
2. The secondary compartment door shall have a one-piece steel handle and incorporate three-point locking mechanisms.
3. Provide a 50 mm (2 inches) size padlock for each assembly, as approved by the COR. Padlocks shall be keyed to the COR established key set. Firmly attach the padlock to the door assembly by a chain.

2.3 BIL RATING

A. 15 kV class equipment shall have a minimum 95 kV BIL rating.

2.4 TRANSFORMER FUSE ASSEMBLY

A. The primary fuse assembly shall be a combination of externally replaceable Bay-O-Net liquid-immersed fuses in series with liquid-immersed current-limiting fuses.

2.5 PRIMARY CONNECTIONS

A. 200 A dead-front loadbreakwells and inserts for cable sizes shown on the drawings.

B. Surge Arresters: Distribution class, one for each primary phase, complying with IEEE C62.11, supported from tank wall.

2.6 MEDIUM-VOLTAGE SWITCH

A. The transformer primary disconnect switch shall be an oil-immersed, internal, gang-operated, load-interrupter type, rated at ampacity and system voltage as shown on the drawings, with a minimum momentary withstand rating of not less than the calculated available fault current shown on the drawings.

B. For loop feeds, switch shall be a four-position, V-blade manual switch located in the medium-voltage compartment and hot-stick-operated.

2.7 MEDIUM-VOLTAGE TERMINATIONS

A. Terminate the medium-voltage cables in the primary compartment with 200 A loadbreak premolded rubber elbow connectors, suitable for submersible applications. Elbow connectors shall have a semi-conductive shield material covering the housing. The separable connector system shall include the loadbreak elbow, the bushing insert, and the bushing well. Separable connectors shall comply with the requirements of IEEE 386, and shall be interchangeable between suppliers. Allow sufficient slack in medium-voltage cable, ground, and drain wires to permit elbow connectors to be moved to their respective parking stands.

B. Ground metallic cable shield with a cable shield grounding adapter, consisting of a solderless connector enclosed in watertight rubber housing covering the entire assembly, bleeder wire, and ground braid.

2.9 TRANSFORMERS

A. Transformer ratings shall be as shown on drawings. kVA ratings shown on the drawings are for continuous duty without the use of cooling fans.

B. Temperature rises shall not exceed the NEMA TR 1 of 65˚ C (149˚ F) by resistance.

C. Transformer insulating material shall be less flammable, edible-seed-oil based, and UL listed as complying with NFPA 70 requirements for fire point of not less than 300˚ C (600˚ F) when tested according to ASTM D 92. Liquid shall be biodegradable and nontoxic.

D. Transformer impedance shall be not less than 4-1/2% for sizes 150 kVA and larger. Impedance shall be as shown on the drawings.

E. Sound levels shall conform to NEMA TR 1 standards.

F. Primary and Secondary Windings for Three-Phase Transformers:

1. Primary windings shall be wye-connected.
2. Secondary windings shall be wye-connected, except where otherwise indicated on the drawings. Provide isolated neutral bushings for secondary wye-connected transformers.
3. Secondary leads shall be brought out through pressure-tight epoxy bushings.

G. Primary windings shall have four 2-1/2% full-capacity voltage taps; two taps above and two taps below rated voltage.

H. Core and Coil Assemblies:

1. Cores shall be grain-oriented, non-aging, silicon steel to minimize losses.
2. Core and coil assemblies shall be rigidly braced to withstand the stresses caused by rough handling during shipment, and stresses caused by any possible short-circuit currents.
3. Coils shall be continuous-winding type without splices except for taps. Material shall be copper.
4. Coil and core losses shall be optimum for efficient operation.
5. Primary, secondary, and tap connections shall be brazed or pressure type.
6. Provide end fillers or tie-downs for coil windings.

I. The transformer tank, cover, and radiator gauge thickness shall not be less than that required by ANSI.

J. Accessories:

1. A transformer nameplate shall be mounted on the outside of enclosure in addition to any required interior labeling.
2. All included gauges and instrumentation devices shall be located outside of the cable compartments such that access to the does not require exposure to any live circuits. Devices shall be located in a separate NEMA 4 rated enclosure with hinged cover and padlock provisions. Externally mounted devices shall include the following:

liquid level gauge, dial-type thermometer, pressure/vacuum gauge, pressure relief valve, and transformer fluid sampling valve.

3. IR inspection windows shall be provided to provide visibility of high and low voltage connections without opening enclosure doors.
4. Provide standard NEMA features, accessories, and the following:
   a. No-load tap changer. Provide warning sign.
   b. Lifting, pulling, and jacking facilities.
   c. Globe-type valve for oil filtering and draining, including sampling device.
   d. Pressure relief valve.
   e. Liquid level gauge and filling plug.
   f. A grounding pad in the medium- and low-voltage compartments.
   g. A diagrammatic nameplate.
   h. Dial-type liquid thermometer with a maximum reading pointer and an external reset.
   i. Hot stick. Securely fasten hot stick within low-voltage compartment.
5. The accessories shall be made accessible within the compartments without disassembling trims and covers.

K. Transformers shall meet the energy conservation standards for transformers per the United States Department of Energy 10 CFR Part 431.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install transformers outdoors, as shown on the drawings, in accordance with the NEC, and as recommended by the manufacturer.

B. Anchor transformers with rustproof bolts, nuts, and washers not less than 12 mm (1/2 inch) diameter, in accordance with manufacturer’s instructions, and as shown on drawings.

C. Mount transformers on concrete slab. Unless otherwise indicated, the slab shall be at least 200 mm (8 inches) thick, reinforced with a 150 by 150 mm (6 by 6 inches) No. 6 mesh placed uniformly 100 mm (4 inches) from the top of the slab. Slab shall be placed on a 150 mm (6 inches) thick, well-compacted gravel base. The top of the concrete slab shall be approximately 100 mm (4 inches) above the finished grade. Edges above grade shall have 12-1/2 mm (1/2 inch) chamfer. The slab shall be of adequate size to project at least 200 mm (8 inches) beyond the

equipment. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 75 mm (3 inches) above slab surface. Concrete work shall be as specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.

D. Grounding:

1. Ground each transformer in accordance with the requirements of the NEC. Install ground rods per the requirements of Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS, to maintain a maximum resistance of 5 ohms to ground.
2. Connect the ground rod to the ground pads in the medium- and low-voltage compartments.
3. Install and connect the cable shield grounding adapter per the manufacturer’s instructions. Connect the bleeder wire of the cable shield grounding adapter to the loadbreak or deadbreak elbow grounding point with minimum No. 14 AWG wire and connect the ground braid to the grounding system with minimum No. 6 AWG bare copper wire. Use soldered or mechanical grounding connectors listed for this purpose.

3.2 ACCEPTANCE CHECKS AND TESTS

A. Perform manufacturer’s required field tests in accordance with the manufacturer's recommendations. In addition, include the following:

1. Visual Inspection and Tests:
   a. Compare equipment nameplate data with specifications and approved shop drawings.
   b. Inspect physical and mechanical condition. Check for damaged or cracked bushings and liquid leaks.
   c. Verify that control and alarm settings on temperature indicators are as specified.
   d. Inspect all field-installed bolted electrical connections, using the calibrated torque-wrench method to verify tightness of accessible bolted electrical connections, and perform thermographic survey after energization under load.
   e. Vacuum-clean transformer interior. Clean transformer enclosure exterior.
   f. Verify correct liquid level in transformer tank.
   g. Verify correct equipment grounding per the requirements of Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

h. Verify the presence and connection of transformer surge arresters, if provided.

i. Verify that the tap-changer is set at rated system voltage.

3.3 FOLLOW-UP VERIFICATION

A. Upon completion of acceptance checks, settings, and tests, the Contractor shall demonstrate that the transformers are in good operating condition and properly performing the intended function.

3.4 SPARE PARTS

A. Deliver the following spare parts for the project to the COR two weeks prior to final inspection:

1. Six insulated protective caps.
2. One spare set of medium-voltage fuses for each size and type of fuse used in the project.

3.5 INSTRUCTION

A. The Contractor shall instruct maintenance personnel, for not less than one 2-hour period, on the maintenance and operation of the equipment on the date requested by the.

---END---

SECTION 26 13 16
MEDIUM-VOLTAGE FUSIBLE INTERRUPTER SWITCHES

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, installation, connection, and testing of medium-voltage fusible interrupter switches, indicated as switches in this section.

1.2 RELATED WORK

A. Section 03 30 00, CAST-IN-PLACE CONCRETE: Requirements for concrete equipment pads.

B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.

C. Section 26 05 13, MEDIUM-VOLTAGE CABLES: Medium-voltage cables and terminations.

D. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path to ground for possible ground fault currents.

E. Section 26 05 73, OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY: Short circuit and coordination study, and requirements for a coordinated electrical system.

1.3 QUALITY ASSURANCE

A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 FACTORY TESTS

A. Factory Tests shall be required.

B. Factory Tests shall be in accordance with Paragraph, MANUFACTURED PRODUCTS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:

1. Switches shall be tested to assure that there are no electrical or mechanical defects. Tests shall be conducted as per UL and ANSI Standards. Factory tests shall be certified. The following tests shall be performed:

a. Verify that fuse sizes and types are in accordance with drawings and
Overcurrent Protective Device Coordination Study.

b. Verify tightness of bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data.
c. Verify operation of mechanical interlocks.
d. Confirm correct operation and sequencing of key-type mechanical interlock systems for multiple switches by attempting closure on locked-open devices, and attempting to open locked-closed devices, and making key exchange with devices operated in off-normal positions.
e. Verify correct phase barrier installation.
f. Verify correct operation of all indicating and control devices.
g. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
h. Exercise all active components.
i. Perform an insulation-resistance test, phase to ground, on each bus section, with phases not under test grounded, in accordance with manufacturer's published data.

1.5 SUBMITTALS

A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:

1. Shop Drawings:
   a. Shop drawings shall be submitted simultaneously with or after the Overcurrent Protective Device Coordination Study.
   b. Submit sufficient information to demonstrate compliance with drawings and specifications.
   c. Provide information such as complete electrical ratings, dimensions and approximate design weights, enclosure types, mounting details, materials, required clearances, cable terminations, fuse sizes and class, interrupting ratings, wiring diagrams, front, side and rear elevations, sectional views, safety features, accessories, and nameplate data.

2. Manuals:
   a. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals including technical data sheets, wiring diagrams, and information for ordering replacement parts.

b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals to the COR two weeks prior to the final inspection.

3. Certification: Two weeks prior to the final inspection, submit the following.
   a. Certification by the manufacturer that switches conform to the requirements of the drawings and specifications.
   b. Certification by the Contractor that switches have been properly installed, adjusted, and tested.

1.6 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

B. American National Standards Institute (ANSI):

C37.57-10.....Metal-Enclosed Interrupter Switchgear Assemblies - Conformance Testing

C37.58-20.....Indoor AC Medium-Voltage Switches for Use in Metal-Enclosed Switchgear - Conformance Test Procedures

C. International Code Council (ICC):

IBC-21.....International Building Code

D. Institute of Electrical and Electronics Engineers (IEEE):

C37.20.3-13.....Metal-Enclosed Interrupter Switchgear (1kV – 38kV)

C37.22-03.....Preferred Ratings and Related Required Capabilities for Indoor AC Medium Voltage Switches Used in Metal-Enclosed Switchgear

C37.42-16.....Specifications for High Voltage (>1000 V)Fuses and Accessories

C37.48-20.....Guide for Application, Operation and Maintenance of High Voltage Fuses, Distribution Enclosed Single Pole Air Switches, Fuse Disconnecting Switches, and Accessories

E. National Fire Protection Association (NFPA):

70-23.....National Electrical Code (NEC)

PART 2 - PRODUCTS

2.1 MEDIUM-VOLTAGE FUSIBLE INTERRUPTER SWITCHES

A. Shall be in accordance with ANSI, IEEE, NFPA, as shown on the drawings, and have the following features:

1. Deadfront air break, three-pole gang-operated, interrupter type.
2. Copper blades.
3. Interphase barriers for the full length of each pole.
4. Protective shield to cover the cable connections on the line terminals.
5. Quick-make, quick-break, manual stored-energy type operation mechanism. The mechanism shall enable the switch to close against a fault equal to the momentary rating of the switch without affecting its continuous current carrying or load interrupting ability.
6. External manual operating handle with lock-open padlocking provisions.
7. When the switches are open, the fuses shall be de-energized.
8. Expulsion fuses.
9. Enclosures:
   a. NEMA type shown on the drawings. Where the types of switch enclosures are not shown, they shall be the NEMA types which are most suitable for the environmental conditions where the switches are being installed.
   b. Doors:
      1) Concealed or semi-concealed hinges shall be used to attach doors. Weld hinges to the enclosure and door.
      2) A separate door for the fuse section. A mechanical interlock shall prevent opening the door unless the switch blades are open, and prevent closing the switch if the door is open.
      3) Three point door locking mechanism with suitable handles and padlocking provisions.
      4) Safety-glass window for viewing the switch blades.
      5) Door stops for the open position.
   c. Finish:
      1) All metal surfaces shall be thoroughly cleaned, phosphatized, primed and painted at the factory.

2) Final finish shall be enamel, lacquer or powder coating. Enamel and powder coatings shall be oven baked. Color shall be light gray.

B. The minimum momentary current rating shall be 80kA.

C. The minimum short-time 2-second current rating shall be 25kA.

D. Provide full length ground bar.

2.2 NAMEPLATES AND MIMIC BUS

A. Nameplates: For Normal Power system, provide laminated black phenolic resin with white core with 12 mm (1/2 inch) engraved lettered nameplates next to each switch. For Essential Electrical System, provide laminated red phenolic resin with white core with 12 mm (1/2 inch) engraved lettered nameplates next to each switch. Nameplates shall indicate equipment served, spaces, or spares in accordance with one line diagram shown on drawings. Nameplates shall be mounted with plated screws on front of switches.

B. Mimic Bus: Provide an approved mimic bus on front of each switch assembly. Color shall be black for the Normal Power system and red for the Essential Electrical System, either factory-painted plastic or metal strips. Plastic tape shall not be used. Use symbols similar to one line diagram shown on drawings. Plastic or metal strips shall be mounted with plated screws.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation shall be in accordance with the NEC, as shown on the drawings, and manufacturer’s instructions.

B. Anchor switches with rustproof bolts, nuts, and washers not less than 13 mm (1/2 inch) diameter, in accordance with manufacturer’s instructions, and as shown on drawings.

C. Exterior Location: Mount switches on concrete slab. Unless otherwise indicated, the slab shall be at least 200 mm (8 inches) thick, reinforced with a 150 by 150 mm (6 by 6 inches) No. 6 mesh placed uniformly 100 mm (4 inches) from the top of the slab. Slab shall be placed on a 150 mm (6 inches) thick, well-compacted gravel base. The top of the concrete slab shall be approximately 100 mm (4 inches) above the finished grade. Edges above grade shall have 15 mm (1/2 inch) chamfer. The slab shall be of adequate size to project at least 200 mm (8 inches) beyond the equipment. Provide conduit turnups and cable

entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 75 mm (3 inches) above slab surface. Concrete work shall be as specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.

D. Interior Location: Mount switches on concrete slab. Unless otherwise indicated, the slab shall be at least 100 mm (4 inches) thick. The top of the concrete slab shall be approximately 100 mm (4 inches) above finished floor. Edges above floor shall have 15 mm (1/2 inch) chamfer. The slab shall be of adequate size to project at least 100 mm (8 inches) beyond the equipment. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 75 mm (3 inches) above slab surface. Concrete work shall be as specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.

3.2 ACCEPTANCE CHECKS AND TESTS

A. Perform in accordance with the manufacturer's recommendations. In addition, include the following:

1. Visual Inspection and Tests:
   a. Compare switches nameplate data with specifications and approved shop drawings.
   b. Inspect physical and mechanical condition.
   c. Confirm correct application of manufacturer's recommended lubricants.
   d. Vacuum-clean switch enclosure interior. Clean switch enclosure exterior.
   e. Verify appropriate anchorage and required area clearances.
   f. Verify appropriate equipment grounding.
   g. Verify correct blade alignment, blade penetration, travel stops, and mechanical operation.
   h. Verify that fuse sizes and types correspond to approved shop drawings.
   i. Inspect all field-installed bolted electrical connections, verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey after energization under load.
   j. Exercise all active components.

k. Confirm correct operation of mechanical interlocks.

m. Inspect all indicating devices for correct operation.

3.3 FOLLOW-UP VERIFICATION

A. Upon completion of acceptance checks, settings, and tests, the Contractor shall show by demonstration in service that switches are in good operating condition, and properly performing the intended function.

3.4 WARNING SIGN

A. Mount on each entrance door of the switchboard room, approximately 1500 mm (5 feet) above grade or floor, a clearly lettered warning sign for warning personnel. The sign shall be attached with rustproof metal screws.

3.5 SPARE PARTS

A. Two weeks prior to the final inspection, provide one (1) set of spare fuses for each switch installed on this project.

3.6 ONE LINE DIAGRAM AND SEQUENCE OF OPERATION

A. At final inspection, an as-built one line diagram shall be laminated or mounted under acrylic glass, and installed in a frame mounted in the switchgear room or in the outdoor switchgear enclosure.

B. Furnish a written sequence of operation for the switchgear and connected line side/load side electrical distribution equipment. The sequence of operation shall be laminated or mounted under acrylic glass, and installed in a frame mounted in the switchgear room or in the outdoor switchgear enclosure.

C. Deliver an additional four copies of the as-built one line diagram and sequence of operation to the COR.

3.7 INSTRUCTION

A. Furnish the services of a factory-trained technician for one 4 hour period for instructing personnel in the operation and maintenance of the switches and related equipment, on the date requested by the COR.

---END---

SECTION 26 22 00
LOW-VOLTAGE TRANSFORMERS

PART 1 – GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, installation, connection, and testing of low-voltage dry-type general-purpose transformers, indicated as transformers in this section.

1.2 RELATED WORK

A. Section 03 30 00, CAST-IN-PLACE CONCRETE: Requirements for concrete equipment pads.

B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.

C. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Low-voltage conductors.

D. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.

E. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduit.

1.3 QUALITY ASSURANCE

A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:

1. Shop Drawings:
   a. Submit sufficient information to demonstrate compliance with drawings and specifications.
   b. Include electrical ratings, dimensions, mounting details, materials, required clearances, terminations, weight, temperature rise, wiring and connection diagrams, plan, front, side, and rear elevations, accessories, and device nameplate data.
2. Manuals:
   a. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals including technical data sheets and wiring diagrams.

1) Schematic signal and control diagrams, with all terminals identified, matching terminal identification in the transformers.
2) Include information for testing, repair, troubleshooting, assembly, disassembly, and factory recommended/required periodic maintenance procedures and frequency.

b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.

3. Certifications: Two weeks prior to final inspection, submit the following.
   a. Certification by the manufacturer that the transformers conform to the requirements of the drawings and specifications.
   b. Certification by the Contractor that the transformers have been properly installed, adjusted, and tested.

1.5 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

B. International Code Council (ICC):
IBC-21.....International Building Code

C. National Fire Protection Association (NFPA):
70-23.....National Electrical Code (NEC)

D. National Electrical Manufacturers Association (NEMA):
TR 1-19.....Transformers, Step Voltage Regulators and Reactors
ST 20-14.....Dry Type Transformers for General Applications

E. Underwriters Laboratories, Inc. (UL):
UL 506-17.....Standard for Safety - Specialty Transformers
UL 1561-11.....Standard for Safety - Dry-Type General Purpose and Power Transformers

F. United States Department of Energy:
10 CFR Part 431.....Energy Efficiency Program for Certain Commercial and Industrial Equipment

PART 2 - PRODUCTS

2.1 TRANSFORMERS

A. Unless otherwise specified, transformers shall be in accordance with NEMA, NFPA, UL and as shown on the drawings.

B. Transformers shall have the following features:

1. Self-cooled by natural convection, isolating windings, indoor dry-type. Autotransformers will not be accepted, except as specifically allowed for buck-boost applications.
2. Rating and winding connections shall be as shown on the drawings.
3. Ratings shown on the drawings are for continuous duty without the use of cooling fans.
4. Copper windings.
5. Insulation systems:
   a. Transformers 30 kVA and larger: UL rated 220 °C (428 °F) system with an average maximum rise by resistance of 150 °C (302 °F) in a maximum ambient of 40 °C (104 °F).
   b. Transformers below 30 kVA: Same as for 30 kVA and larger or UL rated 185 °C (365 °F) system with an average maximum rise by resistance of 115 °C (239 °F) in a maximum ambient of 40 °C (104 °F).
6. Core and coil assemblies:
   a. Rigidly braced to withstand the stresses caused by short-circuit currents and rough handling during shipment.
   b. Cores shall be grain-oriented, non-aging, and silicon steel.
   c. Coils shall be continuous windings without splices except for taps.
   d. Coil loss and core loss shall be minimized for efficient operation.
   e. Primary and secondary tap connections shall be brazed or pressure type.
   f. Coil windings shall have end filters or tie-downs for maximum strength.
7. Average audible sound levels shall comply with NEMA.
8. If not shown on drawings, nominal impedance shall be as permitted by NEMA.
9. Single phase transformers rated 15 kVA through 25 kVA shall have two 5% full capacity taps below normal rated primary voltage. All

transformers rated 30 kVA and larger shall have two 2.5% full capacity taps above, and four 2.5% full capacity taps below normal rated primary voltage.

10. Core assemblies shall be grounded to their enclosures with adequate flexible ground straps.
11. Enclosures:
    a. Comprised of not less than code gauge steel.
    b. Outdoor enclosures shall be NEMA 3R.
    c. Temperature rise at hottest spot shall conform to NEMA Standards, and shall not bake and peel off the enclosure paint after the transformer has been placed in service.
    d. Ventilation openings shall prevent accidental access to live components.
    e. The enclosure at the factory shall be thoroughly cleaned and painted with manufacturer's prime coat and standard finish.
12. Standard NEMA features and accessories, including ground pad, lifting provisions, and nameplate with the wiring diagram and sound level indicated.
13. Dimensions and configurations shall conform to the spaces designated for their installations.
14. Transformers shall meet the energy conservation standards for transformers per the United States Department of Energy’s 10 CFR Part 431.

2.2 NONLINEAR TRANSFORMERS

A. Nonlinear transformers shall be as specified in Paragraph 2.1, with additional features as specified below.
B. Transformers shall be designed to withstand the overheating effects caused by harmonics resulting from non-linear (non-sinusoidal) loads.
C. Neutral rating shall be 200% of rated secondary phase current.
D. Transformers with K factor of 13 shall be provided, if K factor is not shown on contract drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation of transformers shall be in accordance with the NEC, as recommended by the equipment manufacturer and as shown on the drawings.

B. Anchor transformers with rustproof bolts, nuts, and washers, in accordance with manufacturer’s instructions, and as shown on drawings.

C. Install transformers with manufacturer's recommended clearance from wall and adjacent equipment for air circulation. Minimum clearance shall be 150 mm (6 inches).

D. Install transformers on vibration pads designed to suppress transformer noise and vibrations.

3.2 ACCEPTANCE CHECKS AND TESTS

A. Perform tests in accordance with the manufacturer's recommendations. In addition, include the following:

1. Visual Inspection and Tests:
   a. Compare equipment nameplate data with specifications and approved shop drawings.
   b. Inspect physical and mechanical condition.
   c. Inspect all field-installed bolted electrical connections, using the calibrated torque-wrench method to verify tightness of accessible bolted electrical connections.
   d. Perform specific inspections and mechanical tests as recommended by manufacturer.
   e. Verify correct equipment grounding.
   f. Verify proper secondary phase-to-phase and phase-to-neutral voltage after energization and prior to connection to loads.

3.3 FOLLOW-UP VERIFICATION

A. Upon completion of acceptance checks, settings, and tests, the contractor shall demonstrate that the transformers are in good operating condition, and properly performing the intended function.

---END---

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SECTION 26 24 13
DISTRIBUTION SWITCHBOARDS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, installation, connection, and testing of the low-voltage circuit-breaker distribution switchboards, indicated as switchboard(s) in this section.

1.2 RELATED WORK

A. Section 03 30 00, CAST-IN-PLACE CONCRETE: Requirements for concrete equipment pads.

B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.

C. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Low-voltage conductors.

D. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible fault currents.

E. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduit.

F. Section 26 05 73, OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY: Short circuit and coordination study, and requirements for a coordinated electrical system.

G. Section 26 43 13, SURGE PROTECTIVE DEVICES: Surge protective devices for switchboards.

1.3 QUALITY ASSURANCE

A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 FACTORY TESTS

A. Factory Tests shall be required.

B. Factory Tests shall be in accordance with Paragraph, MANUFACTURED PRODUCTS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirement:

1. Tests shall be conducted per NEMA PB 2.
2. Verify that circuit breaker sizes and types correspond to drawings, and the Overcurrent Protective Device Coordination Study.

3. Verify tightness of bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data.
4. Confirm correct operation and sequencing of key-type mechanical interlock systems for multiple circuit breakers by attempting closure on locked-open devices, and attempting to open locked-closed devices, and making key exchange with devices operated in off-normal positions.
5. Exercise all active components.
6. Perform an insulation-resistance test, phase to ground, on each bus section, with phases not under test grounded, in accordance with manufacturer's published data.
7. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential shall be 500 V DC for 300-volt rated cable and 1000 V DC for 600-volt rated cable, or as required if solid-state components or control devices cannot tolerate the applied voltage.
8. If applicable, verify correct function of control transfer relays located in the switchboard with multiple control power sources.
9. Perform phasing checks on double-ended or dual-source switchboards to insure correct bus phasing from each source.

1.5 SUBMITTALS

A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:

1. Shop Drawings:
   a. Switchboard shop drawings shall be submitted simultaneously with or after the Overcurrent Protective Device Coordination Study.
   b. Submit sufficient information to demonstrate compliance with drawings and specifications.
   c. Prior to fabrication of switchboards, submit the following data for approval:
      1) Complete electrical ratings.
      2) Circuit breaker sizes.
      3) Interrupting ratings.
      4) Safety features.
      5) Accessories and nameplate data.

6) Switchboard one line diagram, showing ampere rating, number of bars per phase and neutral in each bus run (horizontal and vertical), bus spacing, equipment ground bus, and bus material.
7) Elementary and interconnection wiring diagrams.
8) Technical data for each component.
9) Dimensioned exterior views of the switchboard.
10) Dimensioned section views of the switchboard.
11) Floor plan of the switchboard.
12) Foundation plan for the switchboard.
13) Provisions and required locations for external conduit and wiring entrances.
14) Approximate design weights.

2. Manuals:
   a. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals, including technical data sheets, wiring diagrams, and information for ordering replacement parts.
      1) Schematic signal and control diagrams, with all terminals identified, matching terminal identification in the switchboard.
      2) Include information for testing, repair, trouble shooting, assembly, disassembly, and factory recommended/required periodic maintenance procedures and frequency.
      3) Provide a replacement and spare parts list. Include a list of tools and instruments for testing and maintenance purposes.
   b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
3. Certifications: Two weeks prior to final inspection, submit the following.
   a. Certification by the manufacturer that the switchboards conform to the requirements of the drawings and specifications.
   b. Certification by the Contractor that the switchboards have been properly installed, adjusted, and tested.

1.6 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by basic designation only.

B. Institute of Engineering and Electronic Engineers (IEEE):

C37.13-15.....Low Voltage AC Power Circuit Breakers Used in Enclosures

C57.13-16.....Instrument Transformers

C62.41.1-08.....Surge Environment in Low-voltage (1000V and less) AC Power Circuits

C62.45-08.....Surge Testing for Equipment connected to Low-Voltage AC Power Circuits

C. International Code Council (ICC):

IBC-21.....International Building Code

D. National Electrical Manufacturer's Association (NEMA):

PB 2-11.....Deadfront Distribution Switchboards

PB 2.1-13.....Proper Handling, Installation, Operation, and Maintenance of Deadfront Distribution Switchboards Rated 600 Volts or Less

E. National Fire Protection Association (NFPA):

70-23.....National Electrical Code (NEC)

F. Underwriters Laboratories, Inc. (UL):

67-18.....Panelboards

489-16.....Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures

891-19.....Switchboards

PART 2 - PRODUCTS

2.1 GENERAL

A. Shall be in accordance with IEEE, NEMA, NFPA, UL, as shown on the drawings, and have the following features:

1. Switchboard shall be a complete, grounded, continuous-duty, integral assembly, dead-front, dead-rear, self-supporting, indoor type switchboard assembly, tamperproof, weatherproof, outdoor type switchboard assembly. Incorporate devices shown on the drawings and all related components required to fulfill operational and functional requirements.

2. Ratings shall not be less than shown on the drawings. Short circuit ratings shall not be less than the available fault current shown in the Overcurrent Protective Device Coordination Study.
3. Switchboard shall conform to the arrangements and details shown on the drawings.
4. Key-type mechanical interlocks for multiple circuit breakers shall be provided as shown on the drawings.
5. Switchboards shall be assembled, connected, and wired at the factory so that only external circuit connections are required at the construction site. Split the structure only as required for shipping and installation. Packaging shall provide adequate protection against rough handling during shipment.
6. All non-current-carrying parts shall be grounded per Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS for additional requirements.
7. Series rated switchboards are not allowed.

2.2 BASIC ARRANGEMENT

A. Type 1: Switchboard shall be front accessible with the following features:
1. Device mounting:
a. Main breaker: Individually mounted and compartmented or group mounted with feeder breakers.
b. Feeder breakers: Group mounted.
2. Section alignment: As shown on the drawings.
3. Accessibility:
a. Main section line and load terminals: Front and side.
b. Distribution section line and load terminals: Front.
c. Through bus connections: Front and end.
4. Bolted line and load connections.
5. Full height wiring gutter covers for access to wiring terminals.

2.3 HOUSING

A. Shall have the following features:
1. Frames and enclosures:
a. The assembly shall be braced with reinforcing gussets using bolted connections to assure rectangular rigidity.
b. The enclosure shall be steel, leveled, and not less than the gauge required by applicable publications.

c. Die-pierce the holes for connecting adjacent structures to insure proper alignment, and to allow for future additions.

d. All bolts, nuts, and washers shall be zinc-plated steel.

B. Finish:

1. All metal surfaces shall be thoroughly cleaned, phosphatized and factory primed prior to applying baked enamel or lacquer finish.

2. Provide a light gray finish for indoor switchboard.

3. Outdoor switchboard:

a. Interior finish shall be light gray.

b. Exterior finishes shall be as specified in the Section 09 06 00, SCHEDULE FOR FINISHES.

c. The underside of the switchboard shall be treated with corrosion resistant compounds, epoxy resin or rubberized sealing compound.

2.4 BUSES

A. Bus Bars and Interconnections:

1. Provide copper phase and neutral buses, fully rated for the amperage as shown on the drawings for the entire length of the switchboard. Bus laminations shall have a minimum of 6 mm (1/4 inch) spacing.

2. Mount the buses on appropriately spaced insulators and brace to withstand the available short circuit currents.

3. The bus and bus compartment shall be designed so that the acceptable NEMA standard temperature rises are not exceeded.

4. Install a copper ground bus the full length of the switchboard assembly.

5. Main Bonding Jumper: An un-insulated copper bus, size as shown on drawings, shall interconnect the neutral and ground buses, when the switchboard is used to establish the system common ground point.

6. All bolts, nuts, and washers shall be zinc-plated steel. Bolts shall be torqued to the values recommended by the manufacturer.

7. Make provisions for future bus extensions by means of bolt holes or other approved method.

2.5 MAIN CIRCUIT BREAKERS

A. Type I or Type II Switchboards: Provide molded case main circuit breakers as shown on the drawings. Circuit breakers shall be the solid state adjustable trip type.

1. Trip units shall have field adjustable tripping characteristics as follows:

a. Long time pickup.
b. Long time delay.
c. Short time pickup.
d. Short time delay.
e. Instantaneous.

2. Breakers with same frame size shall be interchangeable with each other.
3. Breakers shall be fully rated.

2.6 FEEDER CIRCUIT BREAKERS

A. Provide molded case circuit breakers as shown on the drawings.

B. Adjustable Trip Molded Case Circuit Breakers:
1. Provide molded case, solid state adjustable trip type circuit breakers.
2. Trip units shall have field adjustable tripping characteristics as follows:
a. Long time pickup.
b. Long time delay.
c. Short time pickup.
d. Short time delay.
e. Instantaneous.
3. Breakers with same frame size shall be interchangeable with each other.

2.8 SURGE PROTECTIVE DEVICES

A. Refer to Section 26 43 13, SURGE PROTECTIVE DEVICES.

2.10 OTHER EQUIPMENT

A. Furnish tools and accessories required for circuit breaker and switchboard test, inspection, maintenance, and proper operation.

2.11 CONTROL WIRING

A. Switchboard control wires shall not be less than No. 14 AWG copper 600 volt rated. Install wiring complete at the factory, adequately bundled and protected. Provide separate control circuit fuses in each breaker compartment and locate for ease of access and maintenance.

2.12 NAMEPLATES AND MIMIC BUS

A. Nameplates: For Normal Power system, provide laminated black phenolic resin with white core with 12 mm (1/2 inch) engraved lettered nameplates next to each circuit breaker. For Essential Electrical System, provide laminated red phenolic resin with white core with 12 mm

(1/2 inch) engraved lettered nameplates next to each circuit breaker. Nameplates shall indicate equipment served, spaces, or spares in accordance with one line diagram shown on drawings. Nameplates shall be mounted with plated screws on front of breakers or on equipment enclosure next to breakers. Mounting nameplates only with adhesive is not acceptable.

B. Mimic Bus: Provide an approved mimic bus on front of each switchboard assembly. Color shall be black for the Normal Power system and red for the Essential Electrical System, either factory-painted plastic or metal strips. Plastic tape shall not be used. Use symbols similar to one line diagram shown on drawings. Plastic or metal strips shall be mounted with plated screws. Provide IR inspection windows to provide visibility of connections.

2.13 ACCESSORIES

1. Provide IR inspection windows to provide visibility of connections.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install switchboards in accordance with the NEC, as shown on the drawings, and as recommended by the manufacturer.

B. Anchor switchboards with rustproof bolts, nuts, and washers not less than 13 mm (1/2 inch) diameter, in accordance with manufacturer’s instructions, and as shown on drawings.

C. Exterior Location. Mount switchboard on concrete slab. Unless otherwise indicated, the slab shall be at least 200 mm (8 inches) thick, reinforced with a 150 by 150 mm (6 by 6 inches) No. 6 mesh placed uniformly 100 mm (4 inches) from the top of the slab. Slab shall be placed on a 150 mm (6 inches) thick, well-compacted gravel base. The top of the concrete slab shall be approximately 100 mm (4 inches) above the finished grade. Edges above grade shall have 12.5 mm (1/2 inch) chamfer. The slab shall be of adequate size to project at least 200 mm (8 inches) beyond the equipment. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 75 mm (3 inches) above slab surface. Concrete work shall be as specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.

D. Interior Location. Mount switchboard on concrete slab. Unless otherwise indicated, the slab shall be at least 100 mm (4 inches) thick. The top of the concrete slab shall be approximately 100 mm (4 inches) above finished floor. Edges above floor shall have 12.5 mm (1/2 inch) chamfer. The slab shall be of adequate size to project at least 200 mm (8 inches) beyond the equipment. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 75 mm (3 inches) above slab surface. Concrete work shall be as specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.

3.2 ACCEPTANCE CHECKS AND TESTS

A. Perform in accordance with the manufacturer's recommendations. In addition, include the following:

1. Visual Inspection and Tests:
   a. Compare equipment nameplate data with specifications and approved shop drawings.
   b. Inspect physical, electrical, and mechanical condition.
   c. Verify appropriate anchorage, required area clearances, and correct alignment.
   d. Verify that circuit breaker sizes and types correspond to approved shop drawings.
   e. Verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey after energization.
   f. Confirm correct operation and sequencing of key-type mechanical interlock systems.
   g. Vacuum-clean switchboard enclosure interior. Clean switchboard enclosure exterior.
   h. Inspect insulators for evidence of physical damage or contaminated surfaces.
   i. Verify correct shutter installation and operation.
   j. Exercise all active components.
   k. Verify the correct operation of all sensing devices, alarms, and indicating devices.
   l. Verify that vents are clear.
2. Electrical tests:
   a. Perform insulation-resistance tests on each bus section.

b. Perform insulation-resistance test on control wiring; do not perform this test on wiring connected to solid-state components.

c. Perform phasing check on double-ended switchboards to ensure correct bus phasing from each source.

3.3 FOLLOW-UP VERIFICATION

A. Upon completion of acceptance checks, settings, and tests, the Contractor shall show by demonstration in service that the switchboard is in good operating condition and properly performing the intended function.

3.4 WARNING SIGN

A. Mount on each entrance door of the switchboard room, approximately 1500 mm (5 feet) above grade or floor, a clearly lettered warning sign for warning personnel. The sign shall be attached with rustproof metal screws.

3.5 ONE LINE DIAGRAM AND SEQUENCE OF OPERATION

A. At final inspection, an as-built one line diagram shall be laminated or mounted under acrylic glass, and installed in a frame mounted in the switchboard room or in the outdoor switchboard enclosure.

B. Furnish a written sequence of operation for the switchboard and connected line side/load side electrical distribution equipment. The sequence of operation shall be laminated or mounted under acrylic glass, and installed in a frame mounted in the switchboard room or in the outdoor switchboard enclosure.

C. Deliver an additional four copies of the as-built one line diagram and sequence of operation to the COR.

3.6 AS-LEFT TRIP UNIT SETTINGS

A. The trip unit settings shall be set in the field by an authorized representative of the switchboard manufacturer per the approved Electrical System Protective Device Study in accordance with Section 26 05 73, OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY.

C. Post a durable copy of the "as-left" trip unit settings in a convenient location in the electrical room or outdoor switchboard enclosure. Deliver four additional copies of the settings to the COR. Furnish this information prior to the activation of the switchboard.

3.7 INSTRUCTION

A. Furnish the services of a factory-trained technician for one, 4-hour training period for instructing personnel in the maintenance and operation of the switchboards, on the dates requested by the COR.

---END---

SECTION 26 24 16
PANELBOARDS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, installation, and connection of panelboards.

1.2 RELATED WORK

A. Section 25 10 10, ADVANCED UTILITY METERING: Requirements for electrical metering.

B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.

C. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Low-voltage conductors.

D. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.

E. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits.

F. Section 26 05 73, OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY: Short circuit and coordination study, and requirements for a coordinated electrical system.

G. Section 26 09 23, LIGHTING CONTROLS: Lighting controls integral to panelboards.

H. Section 26 43 13, SURGE PROTECTIVE DEVICES: Surge protective devices integral to panelboards.

1.3 QUALITY ASSURANCE

A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:

1. Shop Drawings:
   a. Submit sufficient information to demonstrate compliance with drawings and specifications.
   b. Include electrical ratings, dimensions, mounting details, materials, required clearances, terminations, weight, circuit

breakers, wiring and connection diagrams, accessories, and nameplate data.

2. Manuals:
   a. Submit, simultaneously with the shop drawings, complete maintenance and operating manuals including technical data sheets, wiring diagrams, and information for ordering circuit breakers and replacement parts.
      1) Include schematic diagrams, with all terminals identified, matching terminal identification in the panelboards.
      2) Include information for testing, repair, troubleshooting, assembly, and disassembly.
   b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
3. Certifications: Two weeks prior to final inspection, submit the following.
   a. Certification by the manufacturer that the panelboards conform to the requirements of the drawings and specifications.
   b. Certification by the Contractor that the panelboards have been properly installed, adjusted, and tested.

1.5 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

B. International Code Council (ICC):
IBC-21.....International Building Code

C. National Electrical Manufacturers Association (NEMA):
PB 1-11.....Panelboards
250-20.....Enclosures for Electrical Equipment (1,000V Maximum)

D. National Fire Protection Association (NFPA):
70-23.....National Electrical Code (NEC)
70E-21.....Standard for Electrical Safety in the Workplace

E. Underwriters Laboratories, Inc. (UL):
50-15.....Enclosures for Electrical Equipment
67-09.....Panelboards

489-16.....Molded Case Circuit Breakers and Circuit Breaker Enclosures

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Panelboards shall be in accordance with NEC, NEMA, UL, as specified, and as shown on the drawings.

B. Panelboards shall have main breaker or main lugs, bus size, voltage, phases, number of circuit breaker mounting spaces, top or bottom feed, flush or surface mounting, branch circuit breakers, and accessories as shown on the drawings.

C. Panelboards shall be completely factory-assembled with molded case circuit breakers and integral accessories as shown on the drawings or specified herein.

D. Non-reduced size copper bus bars, rigidly supported on molded insulators, and fabricated for bolt-on type circuit breakers.

E. Bus bar connections to the branch circuit breakers shall be the "distributed phase" or "phase sequence" type.

F. Mechanical lugs furnished with panelboards shall be cast, stamped, or machined metal alloys listed for use with the conductors to which they will be connected.

G. Neutral bus shall be 100%rated, mounted on insulated supports.

H. Grounding bus bar shall be equipped with screws or lugs for the connection of equipment grounding conductors.

I. Bus bars shall be braced for the available short-circuit current as shown on the drawings, but not be less than 20,000 A symmetrical for 120/208 V and 120/240 V panelboards, and 14,000 A symmetrical for 277/480 V panelboards.

J. In two-section panelboards, the main bus in each section shall be full size. The first section shall be furnished with subfeed lugs on the line side of main lugs only, or through-feed lugs for main breaker type panelboards, and have field-installed cable connections to the second section as shown on the drawings. Panelboard sections with tapped bus or crossover bus are not acceptable.

K. Series-rated panelboards are not permitted.

2.2 ENCLOSURES AND TRIMS

A. Enclosures:

1. Provide galvanized steel enclosures, with NEMA rating as shown on the drawings or as required for the environmental conditions in which installed.
2. Enclosures shall not have ventilating openings.
3. Enclosures may be of one-piece formed steel or of formed sheet steel with end and side panels welded, riveted, or bolted as required.
4. Provide manufacturer's standard option for prepunched knockouts on top and bottom endwalls.
5. Include removable inner dead front cover, independent of the panelboard cover.

B. Trims:
1. Hinged "door-in-door" type.
2. Interior hinged door with hand-operated latch or latches, as required to provide access only to circuit breaker operating handles, not to energized parts.
3. Outer hinged door shall be securely mounted to the panelboard enclosure with factory bolts, screws, clips, or other fasteners, requiring a key or tool for entry. Hand-operated latches are not acceptable.
4. Inner and outer doors shall open left to right.
5. Trims shall be flush or surface type as shown on the drawings.

2.3 MOLDED CASE CIRCUIT BREAKERS

A. Circuit breakers shall be per UL, NEC, as shown on the drawings, and as specified.
B. Circuit breakers shall be bolt-on type.
C. Circuit breakers shall have minimum interrupting rating as required to withstand the available fault current, but not less than:
1. 120/208 V Panelboard: 20,000 A symmetrical.
2. 120/240 V Panelboard: 20,000 A symmetrical.
3. 277/480 V Panelboard: 14,000 A symmetrical.

D. Circuit breakers shall have automatic, trip free, non-adjustable, inverse time, and instantaneous magnetic trips for less than 400 A frame. Circuit breakers with 400 A frames and above shall have magnetic trip, adjustable from 5x to 10x. Breaker trip setting shall be set in the field, based on the approved protective device study as specified in Section 26 05 71, ELECTRICAL SYSTEM PROTECTIVE DEVICE STUDY.
E. Circuit breaker features shall be as follows:

1. A rugged, integral housing of molded insulating material.
2. Silver alloy contacts.
3. Arc quenchers and phase barriers for each pole.
4. Quick-make, quick-break, operating mechanisms.
5. A trip element for each pole, thermal magnetic type with long time delay and instantaneous characteristics, a common trip bar for all poles and a single operator.
6. Electrically and mechanically trip free.
7. An operating handle which indicates closed, tripped, and open positions.
8. An overload on one pole of a multi-pole breaker shall automatically cause all the poles of the breaker to open.
9. Ground fault current interrupting breakers, shunt trip breakers, lighting control breakers (including accessories to switch line currents), or other accessory devices or functions shall be provided where shown on the drawings.
10. For circuit breakers being added to existing panelboards, coordinate the breaker type with existing panelboards. Modify the panel directory accordingly.

2.4 SURGE PROTECTIVE DEVICES

A. Where shown on the drawings, furnish panelboards with integral surge protective devices. Refer to Section 26 43 13, SURGE PROTECTIVE DEVICES.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation shall be in accordance with the manufacturer’s instructions, the NEC, as shown on the drawings, and as specified.
B. Locate panelboards so that the present and future conduits can be conveniently connected.
D. Install a printed schedule of circuits in each panelboard after approval by the COR. Schedules shall reflect final load descriptions, room numbers, and room names connected to each circuit breaker. Schedules shall be printed on the panelboard directory cards and be installed in the appropriate panelboards
E. Mount panelboards such that the maximum height of the top circuit breaker above the finished floor shall not exceed 1980 mm (78 inches).
F. Provide blank cover for each unused circuit breaker mounting space.

I. Panelboard enclosures shall not be used for conductors feeding through, spliced, or tapping off to other enclosures or devices.

3.2 ACCEPTANCE CHECKS AND TESTS

A. Perform in accordance with the manufacturer's recommendations. In addition, include the following:

1. Visual Inspection and Tests:

a. Compare equipment nameplate data with specifications and approved shop drawings.

b. Inspect physical, electrical, and mechanical condition.

c. Verify appropriate anchorage and required area clearances.

d. Verify that circuit breaker sizes and types correspond to approved shop drawings.

e. To verify tightness of accessible bolted electrical connections, use the calibrated torque-wrench method or perform thermographic survey after energization.

f. Vacuum-clean enclosure interior. Clean enclosure exterior.

3.3 FOLLOW-UP VERIFICATION

A. Upon completion of acceptance checks, settings, and tests, the Contractor shall demonstrate that the panelboards are in good operating condition and properly performing the intended function.

---END---

SECTION 26 27 26
WIRING DEVICES

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, installation, connection, and testing of wiring devices.

1.2 RELATED WORK

A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements that are common to more than one section of Division 26.

B. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Cables and wiring.

C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path to ground for possible ground fault currents.

D. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduit and boxes.

E. Section 26 51 00, INTERIOR LIGHTING: Fluorescent ballasts and LED drivers for use with manual dimming controls.

1.3 QUALITY ASSURANCE

A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:

1. Shop Drawings:
   a. Submit sufficient information to demonstrate compliance with drawings and specifications.
   b. Include electrical ratings, dimensions, mounting details, construction materials, grade, and termination information.
2. Manuals:
   a. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals, including technical data sheets and information for ordering replacement parts.

b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.

3. Certifications: Two weeks prior to final inspection, submit the following.
   a. Certification by the manufacturer that the wiring devices conform to the requirements of the drawings and specifications.
   b. Certification by the Contractor that the wiring devices have been properly installed and adjusted.

1.5 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by basic designation only.

B. National Electrical Manufacturers Association (NEMA):
WD 1-99(R2020).....General Color Requirements for Wiring Devices
WD 6-16 .....Wiring Devices – Dimensional Specifications

C. National Fire Protection Association (NFPA):
70-23.....National Electrical Code (NEC)
99-21.....Health Care Facilities

D. Underwriter’s Laboratories, Inc. (UL):
5-16.....Surface Metal Raceways and Fittings
20-18.....General-Use Snap Switches
231-16.....Power Outlets
467-13.....Grounding and Bonding Equipment
498-17.....Attachment Plugs and Receptacles
943-16.....Ground-Fault Circuit-Interrupters
1449-21.....Surge Protective Devices
1472-15.....Solid State Dimming Controls

PART 2 - PRODUCTS

2.1 RECEPTACLES

A. General: All receptacles shall comply with NEMA, NFPA, UL, and as shown on the drawings.

1. Mounting straps shall be nickel plated brass, brass, nickel plated steel or galvanize steel with break-off plaster ears, and shall include a self-grounding feature. Terminal screws shall be brass, brass plated or a copper alloy metal.

2. Receptacles shall have provisions for back wiring with separate metal clamp type terminals (four minimum) and side wiring from four captively held binding screws.

B. Duplex Receptacles - Hospital-grade: shall be listed for hospital grade, single phase, 20 ampere, 120 volts, 2-pole, 3-wire, NEMA 5-20R, with break-off feature for two-circuit operation.

1. Bodies shall be ivory in color.
2. Switched duplex receptacles shall be wired so that only the top receptacle is switched. The lower receptacle shall be unswitched.
3. Duplex Receptacles on Emergency Circuit:
   a. In rooms without emergency powered general lighting, the emergency receptacles shall be of the self-illuminated type.
4. Ground Fault Current Interrupter (GFCI) Duplex Receptacles: Shall be an integral unit, hospital-grade, suitable for mounting in a standard outlet box, with end-of-life indication and provisions to isolate the face due to improper wiring. GFCI receptacles shall be self-test receptacles in accordance with UL 943.
   a. Ground fault interrupter shall consist of a differential current transformer, self-test, solid state sensing circuitry and a circuit interrupter switch. Device shall have nominal sensitivity to ground leakage current of 4-6 milliamperes and shall function to interrupt the current supply for any value of ground leakage current above five milliamperes (+ or – 1 milliampere) on the load side of the device. Device shall have a minimum nominal tripping time of 0.025 second.
   b. Self-test function shall be automatically initiated within 5 seconds after power is activated to the receptacles. Self-test function shall be periodically and automatically performed every 3 hours or less.
   c. End-of-life indicator light shall be a persistent flashing or blinking light to indicate that the GFCI receptacle is no longer in service.
5. Tamper-Resistant Duplex Receptacles:
   a. Bodies shall be gray in color.
      1) Shall permit current to flow only while a standard plug is in the proper position in the receptacle.
      2) Screws exposed while the wall plates are in place shall be the tamperproof type.

C. Duplex Receptacles – Non-hospital Grade: shall be the same as duplex receptacles – hospital grade in accordance with sections 2.1A and 2.1B of this specification, except for the hospital grade listing.
   1. Bodies shall be brown nylon.

D. Receptacles - 20, 30, and 50 ampere, 250 Volts: Shall be complete with appropriate cord grip plug.

E. Weatherproof Receptacles: Shall consist of a duplex receptacle, mounted in box with a gasketed, weatherproof, cast metal cover plate and cap over each receptacle opening. The cap shall be permanently attached to the cover plate by a spring-hinged flap. The weatherproof integrity shall not be affected when heavy duty specification or hospital grade attachment plug caps are inserted. Cover plates on outlet boxes mounted flush in the wall shall be gasketed to the wall in a watertight manner.

F. Surge Protective Receptacles shall have integral surge suppression in line to ground, line to neutral, and neutral to ground modes.
   1. Surge Protective Components: Multiple metal-oxide varistors; with a nominal clamp-level rating of 400 Volts, and minimum single transient pulse energy dissipation of 210 Joules.
   2. Active Surge Protective Indication: LED, visible in face of device to indicate device is active or no longer in service.

2.2 TOGGLE SWITCHES

A. Toggle switches shall be totally enclosed tumbler type with nylon bodies. Handles shall be ivory in color unless otherwise specified or shown on the drawings.
   1. Switches installed in hazardous areas shall be explosion-proof type in accordance with the NEC and as shown on the drawings.
   2. Shall be single unit toggle, butt contact, quiet AC type, heavy-duty general-purpose use with an integral self grounding mounting strap with break-off plasters ears and provisions for back wiring with separate metal wiring clamps and side wiring with captively held binding screws.
   3. Switches shall be rated 20 amperes at 120-277 Volts AC.

2.4 WALL PLATES

A. Wall plates for switches and receptacles shall be type smooth nylon. Oversize plates are not acceptable.

B. Color shall be ivory unless otherwise specified.

C. For receptacles or switches mounted adjacent to each other, wall plates shall be common for each group of receptacles or switches.

D. In areas requiring tamperproof wiring devices, wall plates shall be type 302 stainless steel, and shall have tamperproof screws and beveled edges.

E. Duplex Receptacles on Emergency Circuit: Wall plates shall be red nylon with the word "EMERGENCY" engraved in 6 mm (1/4 inch) white letters.

2.5 SURFACE MULTIPLE-OUTLET ASSEMBLIES

A. Shall have the following features:

1. Enclosures:

a. Thickness of steel shall be not less than 1 mm (0.040 inch) for base and cover. Nominal dimensions shall be 40 mm x 70 mm (1-1/2 inches by 2-3/4 inches) with inside cross sectional area not less than 2250 square mm (3-1/2 square inches). The enclosures shall be thoroughly cleaned, phosphatized, and painted at the factory with primer and the manufacturer's standard baked enamel finish.

2. Receptacles shall be duplex.See paragraph 'RECEPTACLES' in this Section. Device cover plates shall be the manufacturer's standard corrosion resistant finish and shall not exceed the dimensions of the enclosure.

3. Unless otherwise shown on drawings, receptacle spacing shall be 600 mm (24 inches) on centers.

4. Conductors shall be as specified in Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLE.

5. Installation fittings shall be the manufacturer’s standard bends, offsets, device brackets, inside couplings, wire clips, elbows, and other components as required for a complete system.

6. Bond the assemblies to the branch circuit conduit system.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation shall be in accordance with the NEC and as shown as on the drawings.

B. Install wiring devices after wall construction and painting is complete.

C. The ground terminal of each wiring device shall be bonded to the outlet box with an approved green bonding jumper, and also connected to the branch circuit equipment grounding conductor.

D. Outlet boxes for toggle switches and manual dimming controls shall be mounted on the strike side of doors.
E. Provide barriers in multi-gang outlet boxes to comply with the NEC.
F. Coordinate the electrical work with the work of other trades to ensure that wiring device flush outlets are positioned with box openings aligned with the face of the surrounding finish material. Pay special attention to installations in cabinet work, and in connection with laboratory equipment.
G. Exact field locations of floors, walls, partitions, doors, windows, and equipment may vary from locations shown on the drawings. Prior to locating sleeves, boxes and chases for roughing-in of conduit and equipment, the Contractor shall coordinate exact field location of the above items with other trades.
H. Install wall switches 1.2 M (48 inches) above floor, with the toggle OFF position down.
I. Install wall dimmers 1.2 M (48 inches) above floor.
J. Install receptacles 450 mm (18 inches) above floor, and 152 mm (6 inches) above counter backsplash or workbenches. Install specific-use receptacles at heights shown on the drawings.
K. Install horizontally mounted receptacles with the ground pin to the right.
L. When required or recommended by the manufacturer, use a torque screwdriver. Tighten unused terminal screws.
M. Label device plates with a permanent adhesive label listing panel and circuit feeding the wiring device.

3.2 ACCEPTANCE CHECKS AND TESTS

A. Perform manufacturer’s required field checks in accordance with the manufacturer's recommendations, and the latest NFPA 99. In addition, include the following:
   1. Visual Inspection and Tests:
      a. Inspect physical and electrical conditions.
      b. Vacuum-clean surface metal raceway interior. Clean metal raceway exterior.
      c. Test wiring devices for damaged conductors, high circuit resistance, poor connections, inadequate fault current path, defective devices, or similar problems using a portable receptacle tester. Correct circuit conditions, remove

malfunctioning units and replace with new, and retest as specified above.

d. Test GFCI receptacles.

2. Receptacle testing in the Patient Care Spaces, such as retention force of the grounding blade of each receptacle, shall comply with the latest NFPA 99.

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SECTION 26 29 21
ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, installation, and connection of fused and unfused disconnect switches (indicated as switches in this section), and separately-enclosed circuit breakers for use in electrical systems rated 600 V and below.

1.2 RELATED WORK

A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.

B. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Low-voltage conductors.

C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground faults.

D. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits.

E. Section 26 24 16, PANELBOARDS: Molded-case circuit breakers.

1.3 QUALITY ASSURANCE

A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:

1. Shop Drawings:
   a. Submit sufficient information to demonstrate compliance with drawings and specifications.
   b. Submit the following data for approval:
      1) Electrical ratings, dimensions, mounting details, materials, required clearances, terminations, weight, fuses, circuit breakers, wiring and connection diagrams, accessories, and device nameplate data.

2. Manuals:
   a. Submit complete maintenance and operating manuals including technical data sheets, wiring diagrams, and information for ordering fuses, circuit breakers, and replacement parts.
      1) Include schematic diagrams, with all terminals identified, matching terminal identification in the enclosed switches and circuit breakers.
      2) Include information for testing, repair, troubleshooting, assembly, and disassembly.
   b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
3. Certifications: Two weeks prior to final inspection, submit the following.
   a. Certification by the manufacturer that the enclosed switches and circuit breakers conform to the requirements of the drawings and specifications.
   b. Certification by the Contractor that the enclosed switches and circuit breakers have been properly installed, adjusted, and tested.

1.5 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

B. International Code Council (ICC):
IBC-21.....International Building Code

C. National Electrical Manufacturers Association (NEMA):
FU l-12.....Low Voltage Cartridge Fuses
KS l-13.....Heavy Duty Enclosed and Dead-Front Switches (600 Volts Maximum)

D. National Fire Protection Association (NFPA):
70-23.....National Electrical Code (NEC)

E. Underwriters Laboratories, Inc. (UL):
98-16.....Enclosed and Dead-Front Switches
248 1-11.....Low Voltage Fuses

489-16.....Molded Case Circuit Breakers and Circuit Breaker Enclosures

PART 2 - PRODUCTS

2.1 FUSED SWITCHES RATED 600 AMPERES AND LESS

A. Switches shall be in accordance with NEMA, NEC, UL, as specified, and as shown on the drawings.

B. Shall be NEMA classified Heavy Duty (HD) for 240 V switches, and NEMA classified Heavy Duty (HD) for 480 V switches.

C. Shall be horsepower (HP) rated.

D. Shall have the following features:

1. Switch mechanism shall be the quick-make, quick-break type.
2. Copper blades, visible in the open position.
3. An arc chute for each pole.
4. External operating handle shall indicate open and closed positions, and have lock-open padlocking provisions.
5. Mechanical interlock shall permit opening of the door only when the switch is in the open position, defeatable to permit inspection.
6. Fuse holders for the sizes and types of fuses specified.
7. Solid neutral for each switch being installed in a circuit which includes a neutral conductor.
8. Ground lugs for each ground conductor.
9. Enclosures:
   a. Shall be the NEMA types shown on the drawings.
   b. Where the types of switch enclosures are not shown, they shall be the NEMA types most suitable for the ambient environmental conditions.
   c. Shall be finished with manufacturer’s standard gray baked enamel paint over pretreated steel.
10. Electrically operated switches shall only be installed where shown on the drawings.

2.2 UNFUSED SWITCHES RATED 600 AMPERES AND LESS

A. Shall be the same as fused switches, but without provisions for fuses.

2.4 MOTOR RATED TOGGLE SWITCHES

A. Type 1, general purpose for single-phase motors rated up to 1 horsepower.

B. Quick-make, quick-break toggle switch with external reset button and thermal overload protection matched to nameplate full-load current of actual protected motor.

2.5 CARTRIDGE FUSES

A. Shall be in accordance with NEMA FU 1.

B. Motor Branch Circuits: Class RK1, time delay.

2.6 SEPARATELY-ENCLOSED CIRCUIT BREAKERS

A. Provide circuit breakers in accordance with the applicable requirements in Section 26 24 16, PANELBOARDS.

B. Enclosures shall be the NEMA types shown on the drawings. Where the types are not shown, they shall be the NEMA type most suitable for the ambient environmental conditions.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation shall be in accordance with the NEC, as shown on the drawings, and manufacturer’s instructions.

C. Fused switches shall be furnished complete with fuses. Arrange fuses such that rating information is readable without removing the fuses.

3.2 ACCEPTANCE CHECKS AND TESTS

A. Perform in accordance with the manufacturer's recommendations. In addition, include the following:

1. Visual Inspection and Tests:
   a. Compare equipment nameplate data with specifications and approved shop drawings.
   b. Inspect physical, electrical, and mechanical condition.
   c. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method.
   d. Vacuum-clean enclosure interior. Clean enclosure exterior.

3.3 SPARE PARTS

A. Two weeks prior to the final inspection, furnish one complete set of spare fuses for each fused disconnect switch installed on the project. Deliver the spare fuses to the COR.

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SECTION 26 32 13
ENGINE GENERATORS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, installation, connection, and testing of the low-voltage engine generators.

1.2 RELATED WORK

A. Section 03 30 00, CAST-IN-PLACE CONCRETE: Requirements for concrete equipment pads.

B. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT: Requirements for pipe and equipment support and noise control.

C. Section 23 07 11, HVAC, PLUMBING, AND BOILER PLANT INSULATION: Requirements for hot piping and equipment insulation.

D. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.

E. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Low-voltage conductors.

F. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.

G. Section 26 05 73, OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY: Short circuit and coordination study, and requirements for a coordinated electrical system.

H. Section 26 24 13, DISTRIBUTION SWITCHBOARDS: Requirements for secondary distribution switchboards.

I. Section 26 36 23, AUTOMATIC TRANSFER SWITCHES: Requirements for automatic transfer switches for use with engine generators.

1.3 QUALITY ASSURANCE

A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

B. A factory-authorized representative shall be capable of providing emergency maintenance and repairs at the project site within 4 hours maximum of notification.

1.4 FACTORY TESTS

A. Factory Tests shall be required.

B. Factory Tests shall be in accordance with Paragraph, MANUFACTURED PRODUCTS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirement:

1. Load Test: Shall include two hours while the engine generator is delivering 100% of the specified kW, and four hours while the engine generator is delivering 80% of the specified kW. During this test, record the following data at 20-minute intervals:

Time	Engine RPM	Oil Temperature Out
kW	Water Temperature In	Fuel Pressure
Voltage	Water Temperature Out	Oil Pressure
Amperes	Oil Temperature In	Ambient Temperature

2. Cold Start Test: Record time required for the engine generator to develop specified voltage, frequency, and kW load from a standstill condition with engine at ambient temperature.
3. The manufacturer shall furnish fuel, load banks, testing instruments, and all other equipment necessary to perform these tests.

1.5 SUBMITTALS

A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:

1. Shop Drawings:
   a. Submit sufficient information to demonstrate compliance with drawings and specifications.
   b. Scaled drawings, showing plan views, side views, elevations, and cross-sections.
2. Diagrams:
   a. Control system diagrams, control sequence diagrams or tables, wiring diagrams, interconnections diagrams (between engine generators, automatic transfer switches, paralleling switchgear, local control cubicles, remote annunciator panels, and fuel storage tanks, as applicable), and other like items.
3. Technical Data:

a. Published ratings, catalog cuts, pictures, and manufacturer's specifications for engine generator, governor, voltage regulator, radiator, muffler, dampers, day tank, pumps, fuel tank, batteries and charger, jacket heaters, torsional vibration, and control and supervisory equipment.
b. Description of operation.
c. Short-circuit current capacity and sub-transient reactance.
d. Sound power level data.

4. Calculations:
   a. Calculated performance derations appropriate to installed environment.
5. Manuals:
   a. When submitting the shop drawings, submit complete maintenance and operating manuals, to include the following:
      1) Technical data sheets.
      2) Wiring diagrams.
      3) Include information for testing, repair, troubleshooting, and factory recommended periodic maintenance procedures and frequency.
      4) Provide a replacement and spare parts list. Include a list of tools and instruments for testing and maintenance purposes.
   b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
6. Test Reports:
   a. Submit certified factory test reports for approval.
   b. Submit field test reports two weeks prior to the final inspection.
7. Certifications:
   a. Prior to fabrication of the engine generator, submit the following for approval:
      1) A certification in writing that an engine generator of the same model and configuration, with the same bore, stroke, number of cylinders, and equal or higher kW/kVA ratings as the proposed engine generator, has been operating satisfactorily with connected loads of not less than 75% of the specified kW/kVA rating, for not fewer than 2,000 hours without any

failure of a crankshaft, camshaft, piston, valve, injector, or governor system.

2) A certification in writing that devices and circuits will be incorporated to protect the voltage regulator and other components of the engine generator during operation at speeds other than the rated RPM while performing maintenance. Submit thorough descriptions of any precautions necessary to protect the voltage regulator and other components of the system during operation of the engine generator at speeds other than the rated RPM.

3) A certification from the engine manufacturer stating that the engine exhaust emissions meet the applicable federal, state, and local regulations and restrictions. At a minimum, this certification shall include emission factors for criteria pollutants including nitrogen oxides, carbon monoxide, particulate matter, sulfur dioxide, non-methane hydrocarbon, and hazardous air pollutants (HPAs).

b. Prior to installation of the engine generator at the job site, submit certified factory test data.

c. Two weeks prior to the final inspection, submit the following.

1) Certification by the manufacturer that the engine generators conform to the requirements of the drawings and specifications.

2) Certification by the Contractor that the engine generators have been properly installed, adjusted, and tested.

1.6 STORAGE AND HANDLING

A. Engine generators shall withstand shipping and handling stresses in addition to the electrical and mechanical stresses which occur during operation of the system. Protect radiator core with wood sheet.

B. Store the engine generators in a location approved by the COR.

1.7 JOB CONDITIONS

A. Job conditions shall conform to the arrangements and details shown on the drawings. The dimensions, enclosures, and arrangements of the engine generator system shall permit the operating personnel to safely and conveniently operate and maintain the system in the space designated for installation.

1.8 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

B. American Society of Testing Materials (ASTM):

A53/A53M-20.....Standard Specification for Pipe, Steel, Black, and Hot-Dipped, Zinc Coated Welded and Seamless

B88-20.....Specification for Seamless Copper Water Tube

B88M-20.....Specification for Seamless Copper water Tube (Metric)

D975-21.....Diesel Fuel Oils

C. Institute of Electrical and Electronic Engineers (IEEE):

C37.13-15.....Low Voltage AC Power Circuit Breakers Used In Enclosures

C37.90.1-12.....Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus

D. International Code Council (ICC):

IBC-21.....International Building Code

E. International Organization for Standardization (ISO):

8528-1-18.....Reciprocating Internal Combustion Engine-Driven Alternate Current Generating Sets – Part 1: Application, Ratings and Performance

F. National Electrical Manufacturers Association (NEMA):

ICS 6-93(R2016).....Enclosures

ICS 4-15.....Application Guideline for Terminal Blocks

MG 1-16.....Motor and Generators

MG 2-14.....Safety Standard and Guide for Selection, Installation and Use of Electric Motors and Generators

PB 2-11.....Dead-Front Distribution Switchboards

250-20.....Enclosures for Electrical Equipment (1000 Volts Maximum)

G. National Fire Protection Association (NFPA):

30-21.....Flammable and Combustible Liquids Code

37-21.....Installations and Use of Stationary Combustion Engine and Gas Turbines

70-23.....National Electrical Code (NEC)

99-21.....Health Care Facilities

110-22.....Standard for Emergency and Standby Power Systems

H. Underwriters Laboratories, Inc. (UL):

50-15.....Enclosures for Electrical Equipment

142-19.....Steel Aboveground Tanks for Flammable and Combustible Liquids

467-13.....Grounding and Bonding Equipment

489-16.....Molded-Case Circuit Breakers, Molded-Case Switches and Circuit-Breaker Enclosures

508-18.....Industrial Control Equipment

891-19.....Switchboards

1236-15.....Battery Chargers for Charging Engine-Starter Batteries

2085-97.....Insulated Aboveground Tanks for Flammable and Combustible Liquids

2200-20.....Stationary Engine Generator Assemblies

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. The engine generator system shall be in accordance with ASTM, ISO, NEMA, NFPA, UL, as shown on the drawings, and as specified herein.

B. Provide a factory-assembled, wired (except for field connections), complete, fully automatic engine generator system, as well as all associate equipment and devices intended for the operating, control, monitoring, and remote manual stop functions.

C. Engine Generator Parameter Schedule:

1. Power Rating: Emergency Standby
2. Voltage: 277/480V
3. Rated Power: 400kW
4. Power Factor: 0.8 lagging
5. Engine Generator Application: parallel with other generators on an isolated bus
6. Fuel: diesel

7. Voltage Regulation: + 2% (maximum) (No Load to Full Load) (standalone applications)
8. Phases: 3 Phase, Wye
9. Each component of the engine generator system shall be capable of operating at 1500 feet above sea level which will have average ambient air temperature ranging from a minimum of -3 ˚F) in winter to maximum of (105 ˚F) in summer.

D. Assemble, connect, and wire the engine generator at the factory so that only the external connections need to be made at the construction site.

E. Engine Generator Unit shall be factory-painted with manufacturer's primer and standard finishes.

F. Connections between components of the system shall conform to the recommendations of the manufacturer.

G. Couplings, shafts, and other moving parts shall be enclosed and guarded. Guards shall be metal, ruggedly constructed, rigidly fastened, and readily removable for convenient servicing of the equipment without disassembling any pipes and fittings.

H. Engine generator shall have the following features:
1. Factory-mounted on a common, rigid, welded, structural steel base.
2. Engine generator shall be statically and dynamically balanced so that the maximum vibration in the horizontal, vertical, and axial directions shall be limited to 0.15 mm (0.0059 inch), with an overall velocity limit of 24 mm/sec (0.866 inch per second) RMS, for all speeds.
3. The isolators shall be constrained with restraints capable of withstanding static forces in any direction equal to twice the weight of the supported equipment.
4. Shall be capable of operating satisfactorily as specified for not fewer than 10,000 hours between major overhauls.

I. Each engine generator specified for parallel operation shall be configured for automatic parallel operation.

2.2 ENGINE

A. The engine shall be coupled directly to a generator.

B. Minimum four cylinders.

C. The engine shall be able to start in a 4.5 ˚C (40 ˚F) ambient temperature while using No. 2 diesel fuel oil without the use of starting aids such as glow plugs and ether injections.

D. The engine shall be equipped with electric heater for maintaining the coolant temperature between 32-38 °C (90-100 °F), or as recommended by the manufacturer.
   1. Install thermostatic controls, contactors, and circuit breaker-protected circuits for the heaters.
   2. The heaters shall operate continuously except while the engine is operating or the water temperature is at the predetermined level.

2.3 GOVERNOR

A. Isochronous, electronic type.

B. Steady-state speed band at 60 Hz shall not exceed plus or minus 0.33%.

2.4 LUBRICATION OIL SYSTEM

A. Pressurized type.

B. Positive-displacement pump driven by engine crankshaft.

C. Full-flow strainer and full-flow or by-pass filters.

D. Filters shall be cleanable or replaceable type and shall remove particles as small as 3 microns without removing the additives in the oil. For by-pass filters, flow shall be diverted without flow interruption.

E. Extend lube oil sump drain line out through the skid base and terminate it with a drain valve and plug.

F. Provide a 120-volt oil heater for exterior engine generator.

2.5 FUEL SYSTEM

A. Main fuel storage tank(s) shall comply with the requirements of Section 23 10 00, FACILITY FUEL SYSTEMS.

B. Shall comply with NFPA 37 and NFPA 30, and have the following features:
   1. Injection pump(s) and nozzles.
   2. Plungers shall be carefully lapped for precision fit and shall not require any packing.
   3. Filters or screens that require periodic cleaning or replacement shall not be permitted in the injection system assemblies.
   4. Return surplus oil from the injectors to the main storage tank by gravity or a pump.
   5. Filter System:
      a. Dual primary filters shall be located between the main fuel oil storage and day tank.

b. Secondary filters (engine-mounted) shall be located such that the oil will be thoroughly filtered before it reaches the injection system assemblies.
c. Filters shall be cleanable or replaceable type and shall entrap and remove water from oil as recommended by the engine manufacturer.

C. Day Tank:
1. Each engine generator shall be provided with a welded steel integral day tank with double-wall fuel containment.
2. Each day tank shall have capacity to supply fuel to the engine for a 24 hour period at 100% rated load without being refilled, including fuel that is returned to the main fuel storage tank. The calculation of the capacity of each day tank shall incorporate the requirement to stop the supply of fuel into the day tank at 90% of the ultimate volume of the tank.
3. Secure, pipe, and connect the tank adequately for maximum protection from fire hazards, including oil leaks.
4. Incorporate a vent, drain cock, shutoff cocks, and gauge glass. Terminate the vent piping outdoors with mushroom vent cap.
5. Incorporate a float switch on the day tank to control the fuel oil transfer pump and to actuate an alarm in the engine generator control cubicle when the oil level in the tank drops below the level at which the transfer pump should start to refill the tank.
a. The float switch contacts controlling the fuel oil transfer pump shall be set to energize the pump when the liquid level in the tank reaches one-third of the total volume of the tank.
b. The float switch contacts that actuate the low fuel oil day tank alarm device shall be set to alarm and energize the second fuel transfer pump when the liquid level in the tank reaches one-quarter of the total volume of the tank.
6. Day tank and engine supply line elevations shall be below the elevation of the injector return outlet on the engine.

2.6 COOLING SYSTEM

A. Liquid-cooled, closed loop, with fin-tube radiator mounted on the engine generator, and integral engine driven circulating pump, as shown on the drawings.

B. Cooling capacity shall not be less than the cooling requirements of the engine generator and its lubricating oil while operating continuously at 100% of its specified rating.
C. Coolant shall be extended-life antifreeze solution, 50% ethylene glycol and 50% soft water, with corrosion inhibitor additive as recommended by the manufacturer.
E. Fan shall be driven by multiple belts from engine shaft .
F. Coolant hoses shall be flexible, per manufacturer's recommendation.
G. Self-contained thermostatic-control valve shall modulate coolant flow to maintain optimum constant coolant temperature, as recommended by the engine manufacturer.

2.7 AIR INTAKE AND EXHAUST SYSTEMS

A. Air Intake:
1. Provide an engine-mounted air cleaner with replaceable dry filter and dirty filter indicator.
B. Exhaust System:

1. Exhaust Muffler:
Shall be critical grade type and capable of the following noise attenuation:

Octave Band Hertz (Mid Frequency)	Minimum db Attenuation (.0002 Microbar Reference)
31	5
63	10
125	27
500	37
1000	31
2000	26
4000	25
8000	26

2.8 ENGINE STARTING SYSTEM

A. The engine starting system shall start the engine at any position of the flywheel.

B. Electric cranking motor:
   1. Shall be engine-mounted.
   2. Shall crank the engine via a gear drive.
   3. Rating shall be adequate for cranking the cold engine at the voltage provided by the battery system, and at the required RPM during five consecutive starting attempts of 10 seconds cranking each at 10-second intervals, for a total of 50 seconds of actual cranking without damage (the fifth starting attempt will be manually initiated upon failure of a complete engine cranking cycle).

C. Batteries shall be lead-acid high discharge rate type.
   1. Each battery cell shall have minimum and maximum electrolyte level indicators and a flip-top flame arrestor vent cap.
   2. Batteries shall have connector covers for protection against external short circuits.
   3. With the charger disconnected, the batteries shall have sufficient capacity so that the total system voltage does not fall below 85% of the nominal system voltage with the following demands:
      Five consecutive starting attempts of 10 seconds cranking at 10 second intervals for a total of 50 seconds of actual cranking (the fifth starting attempt will be manually initiated upon failure of a complete engine cranking cycle).
   4. Battery racks shall be metal with an alkali-resistant finish and thermal insulation, and secured to the floor.

D. Battery Charger:
   1. A current-limiting battery charger, conforming to UL 1236, shall be provided and shall automatically recharge the batteries. The charger shall 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.
   2. An ammeter shall be provided to indicate charging rate. A voltmeter shall be provided to indicate charging voltage.

2.9 LUBRICATING OIL HEATER

A. Provide a thermostatically-controlled electric heater to automatically maintain the oil temperature within plus or minus 1.7 °C (3 °F) of the control temperature.

2.10 JACKET COOLANT HEATER

A. Provide a thermostatically-controlled electric heater mounted in the engine coolant jacketing to automatically maintain the coolant within plus or minus 1.7 °C (3 °F) of the temperature recommended by the engine manufacturer to meet the starting time specified at the minimum winter outdoor temperature.

2.11 GENERATOR

A. Synchronous, amortisseur windings, bracket-bearing, self-venting, rotating-field type connected directly to the engine.

B. Lifting lugs designed for convenient connection to and removal from the engine.

C. Integral poles and spider, or individual poles dove-tailed to the spider.

D. Designed for sustained short-circuit currents in conformance with NEMA Standards.

E. Designed for sustained operation at 100% of the RPM specified for the engine generator without damage.

F. Telephone influence factor shall conform to NEMA MG 1.

G. Furnished with brushless excitation system or static-exciter-regulator assembly.

H. Nameplates attached to the generator shall show the manufacturer's name, equipment identification, serial number, voltage ratings, field current ratings, kW/kVA output ratings, power factor rating, time rating, temperature rise ratings, RPM ratings, full load current rating, number of phases and frequency, and date of manufacture.

I. The grounded (neutral) conductor shall be electrically isolated from equipment ground and terminated in the same junction box as the phase conductors.

2.12 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Generator circuit breaker shall be molded-case, electronic-trip type, and 100% rated, complying with UL 489. Tripping characteristics shall be adjustable long-time and short-time delay and instantaneous. Provide shunt trip to trip breaker when engine generator is shut down by other protective devices.

B. Overcurrent protective device cubicle shall contain terminations for neutral and equipment grounding conductors as necessary.

2.13 CONTROLS

A. Shall include Engine Generator Control Cubicle(s).

B. General:

1. Control equipment shall be in accordance with UL 508, NEMA ICS-4, ICS-6, and ANSI C37.90.1.
2. Panels shall be in accordance with UL 50.
3. Cubicles shall be in accordance with UL 891.
4. Coordinate controls with the automatic transfer switches shown on the drawings so that the systems will operate as specified.
5. Cubicles:
   a. Code gauge steel: manufacturer's recommended heavy gauge steel with factory primer and light gray finish.
   b. Doors shall be gasketed, attached with concealed or semi-concealed hinges, and shall have a permanent means of latching in closed position.
   c. Panels shall be wall-mounted or incorporated in other equipment as indicated on the drawings or as specified.
   d. Door locks for panels and cubicles shall be keyed identically to operate from a single key.
6. Wiring: Insulated, rated at 600 V.
   a. Install the wiring in vertical and horizontal runs, neatly harnessed.
   b. Terminate all external wiring at heavy duty, pressure-type, terminal blocks.
7. The equipment, wiring terminals, and wires shall be clearly and permanently labeled.
8. The appropriate wiring diagrams shall be laminated or mounted under plexiglass within the frame on the inside of the cubicles and panels.
9. All indicating lamps and switches shall be accessible and mounted on the cubicle doors.
10. Meters shall be per the requirements of Section 25 10 10, ADVANCED UTILITY METERING.
11. The manufacturer shall coordinate the interconnection and programming of the generator controls with all related equipment, including automatic transfer switches and generator paralleling controls as applicable, specified in other sections.

C. Engine generator Control Cubicle:

1. Starting and Stopping Controls:
   a. A three-position, maintained-contact type selector switch with positions marked "AUTOMATIC," "OFF," and "MANUAL." Provide flashing amber light for OFF and MANUAL positions.
   b. A momentary contact push-button switch with positions marked "MANUAL START" and "MANUAL STOP."
   c. Selector switch in AUTOMATIC position shall cause the engine to start automatically when a single pole contact in a remote device closes. When the generator's output voltage increases to not less than 90% of its rated voltage, and its frequency increases to not less than 58 Hz, the remote devices shall transfer the load to the generator. An adjustable time delay relay, in the 0 to 15 minute range, shall cause the engine generator to continue operating without any load after completion of the period of operation with load. Upon completion of the additional 0 to 15 minute (adjustable) period, the engine generator shall stop.
   d. Selector switch in OFF position shall prevent the engine from starting either automatically or manually. Selector switch in MANUAL position shall also cause the engine to start when the manual start push-button is depressed momentarily.
   e. With selector switch is in MANUAL position, depressing the MANUAL STOP push-button momentarily shall stop the engine after a cool-down period.
   f. A maintained-contact, red mushroom-head push-button switch marked "EMERGENCY STOP" will cause the engine to stop without a cool-down period, independent of the position of the selector switch.
2. Engine Cranking Controls:
   a. The cranking cycles shall be controlled by a timer that will be independent of the battery voltage fluctuations.
   b. The controls shall crank the engine through one complete cranking cycle, consisting of four starting attempts of 10 seconds each with 10 seconds between each attempt.
   c. Total actual cranking time for the complete cranking cycle shall be 40 seconds during a 70-second interval.
   d. Cranking shall terminate when the engine starts so that the starting system will not be damaged. Termination of the cranking

shall be controlled by self-contained, speed-sensitive switch. The switch shall prevent re-cranking of the engine until after the engine stops.

e. After the engine has stopped, the cranking control shall reset.

3. Supervisory Controls:

a. Overcrank:

1) When the cranking control system completes one cranking cycle (four starting attempts), without starting the engine, the OVERCRANK signal light and the audible alarm shall be energized.

2) The cranking control system shall lock-out, and shall require a manual reset.

b. Coolant Temperature:

1) When the temperature rises to the predetermined first stage level, the HIGH COOLANT TEMPERATURE - FIRST STAGE signal light and the audible alarm shall be energized.

2) When the temperature rises to the predetermined second stage level, which shall be low enough to prevent any damage to the engine and high enough to avoid unnecessary engine shutdowns, the HIGH COOLANT TEMPERATURE - SECOND STAGE signal light and the audible alarm shall be energized and the engine shall stop.

3) The difference between the first and second stage temperature settings shall be approximately -12 ˚C (10 ˚F).

4) Permanently indicate the temperature settings near the associated signal light.

5) When the coolant temperature drops to below 21 ˚C (70 ˚F), the "LOW COOLANT TEMPERATURE" signal light and the audible alarm shall be energized.

c. Low Coolant Level: When the coolant level falls below the minimum level recommended by the manufacturer, the LOW COOLANT LEVEL signal light and audible alarm shall be energized.

d. Lubricating Oil Pressure:

1) When the pressure falls to the predetermined first stage level, the OIL PRESSURE - FIRST STAGE signal light and the audible alarm shall be energized.

2) When the pressure falls to the predetermined second stage level, which shall be high enough to prevent damage to the engine and low enough to avoid unnecessary engine shutdowns, the OIL PRESSURE - SECOND STAGE signal light and the audible alarm shall be energized and the engine shall stop.
3) The difference between the first and second stage pressure settings shall be approximately 15% of the oil pressure.
4) The pressure settings near the associated signal light shall be permanently displayed so that the running oil pressure can be compared to the target (setpoint) value.

e. Overspeed:
1) When the engine RPM exceeds the maximum RPM recommended by the manufacturer of the engine, the engine shall stop.
2) Simultaneously, the OVERSPEED signal light and the audible alarm shall be energized.

f. Low Fuel - Day Tank:
When the fuel oil level in the day tank decreases to less than the level at which the fuel oil transfer pump should start to refill the tank, the LOW FUEL DAY TANK light and the audible alarm shall be energized.

g. Low Fuel - Main Storage Tank:
When the fuel oil level in the storage tank decreases to less than one-third of total tank capacity, the LOW FUEL-MAIN STORAGE TANK signal light and audible alarm shall be energized.

h. Reset Alarms and Signals:
Overcrank, Coolant Temperature, Coolant Level, Oil Pressure, Overspeed, and Low Fuel signal lights and the associated audible alarms shall require manual reset. A momentary-contact silencing switch and push-button shall silence the audible alarm by using relays or solid state devices to seal in the audible alarm in the de-energized condition. Elimination of the alarm condition shall automatically release the sealed-in circuit for the audible alarm so that it will be automatically energized again when the next alarm condition occurs. The signal lights shall require manual reset after elimination of the condition which caused them to be energized. Install the audible alarm just outside the engine

generator room in a location as directed by the COR. The audible alarm shall be rated for 85 dB at 3 M (10 feet).

i. Generator Breaker Signal Light:

1) A flashing green light shall be energized when the engine generator circuit breaker is in the OPEN or TRIPPED position.

2) Simultaneously, the audible alarm shall be energized.

4. Monitoring Devices:

a. Electric type gauges for the cooling water temperatures and lubricating oil pressures. These gauges may be engine mounted with proper vibration isolation.

b. A running time indicator, totalizing not fewer than 9,999 hours, and an electric type tachometer.

c. A voltmeter, ammeter, frequency meter, kilowatt meter, manual adjusting knob for the output voltage, and the other items shown on the drawings shall be mounted on the front of the generator control panels.

d. Install potential and current transformers as required.

e. Visual Indications:

1) OVERCRANK

2) HIGH COOLANT TEMPERATURE - FIRST STAGE

3) HIGH COOLANT TEMPERATURE - SECOND STAGE

4) LOW COOLANT TEMPERATURE

5) OIL PRESSURE - FIRST STAGE

6) OIL PRESSURE - SECOND STAGE

7) LOW COOLANT LEVEL

8) GENERATOR BREAKER

9) OVERSPEED

10) LOW FUEL - DAY TANK

11) LOW FUEL – MAIN STORAGE TANK

f. Lamp Test: The LAMP TEST momentary contact switch shall momentarily actuate the alarm buzzer and all the indicating lamps.

5. Automatic Voltage Regulator:

a. Shall correct voltage fluctuations rapidly and restore the output voltage to the predetermined level with a minimum amount of hunting.

b. Shall include voltage level rheostat located inside the control cubicle.

c. Provide a 3-phase automatic voltage regulator immune to waveform distortion.

2.14 REMOTE MANUAL STOP STATION

A. Shall be provided per NFPA 101, and shall be a red mushroom-head push-button switch.

B. Shall be connected to the main generator control panel to provide emergency shutdown of the generator.

C. Shall be located outside the room housing the generator.

D. Shall have permanent label reading “EMERGENCY STOP”.

2.15 SOUND-ATTENUATED ENCLOSURE

A. The engine generator and related equipment shall be housed in an outdoor weatherproof enclosure.

B. The enclosure shall be provided with a factory-installed and factory-wired panelboard, 20A 120V receptacles, and LED light fixtures with guards and switches.

C. Enclosure shall be weatherproof and sound-attenuated (maximum 85 dBA at 1525 mm (5 feet) from any side, top and bottom to no more than 75 dBA when measured at 15 M (50 feet) horizontally from any part of the enclosure). Sound ratings shall be based on full load condition of engine generator in a single unit operation condition.

D. Load Center: Generator enclosure shall be provided with load center. Manufacture is to pre=wire all aux power loads internal to generator to load center. Incoming power source to be provided by electrical contractor. Load center description is as follows:

1. 120/208V, 1PH, 3-wire,100A bus, 16 pole
2. 60A/2P main breaker
3. (2) 20A/2P circuit breakers, (6) 20A/1P
4. NEMA 3R enclosure

E. Airflow configuration shall be intake through rear of unit, and discharge air vertically up. Enclosure shall be suitable for winds up to 193 kmh (120 miles per hour) roof load shall be equal to or greater than 200 kg/sq m (40 pounds per square foot) Non-distributed loading as required.

F. The enclosure shall meet the following requirements:

1. Radiator exhaust outlet shall be ducted through the end of the enclosure.
2. All exterior surfaces shall be factory-painted with industrial enamel.
3. Unit shall have sufficient guards to prevent entrance by small animals.
4. Batteries shall fit inside enclosure and alongside the engine generator. Batteries under the generator are not acceptable.
5. The muffler shall be mounted and thermally-insulated inside the enclosure.

2.16 SPARE PARTS

A. For each engine generator:
   1. Six lubricating oil filters.
   2. Six primary fuel oil filters.
   3. Six secondary fuel oil filters.
   4. Six intake air filters.
B. For each battery charger:
   1. Three complete sets of fuses.
C. For each control panel:
   1. Three complete sets of fuses, if applicable.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install concrete bases of dimensions shown on the drawings.
B. Installation of the engine generator shall comply with manufacturer's written instructions and with NFPA 110.
C. Mounting:
   1. Support the base of engine generator on vibration isolators, each isolator bolted to the floor (pad), and the generator base bolted to isolator.
   2. Install sufficient isolators so that the floor (pad) bearing pressure under each isolator is within the floor (pad) loading specification.
   3. Install equal number of isolators on each side of the engine generator's base.
   4. Locate isolators for approximately equal load distribution and deflection per isolator. The base of the engine generator shall be drilled at the factory for the isolator bolts.

5. Isolators shall be shipped loose with the engine generator.
6. All connections between the engine generator and exterior systems, such as fuel lines, electrical connections, and engine exhaust system and air exhaust shroud, shall be flexible.

E. Balance:
1. The vibration velocity in the horizontal, vertical, and axial directions shall not exceed 16.25 mm (0.65 inch) per second peak at any specific frequency. These limits apply to main structural components such as the engine block and the generator frame at the bearings.

F. Connect all components of the generator system so that they will continue to be energized during failure of the normal electrical power supply system.

G. Install piping between engine generator and remote components of cooling, fuel, and exhaust systems.

H. Flexible connection between radiator and exhaust shroud at the wall damper:
1. Install noncombustible flexible connections made of 20-oz neoprene-coated fiberglass fabric approximately 150 mm (6 inches) wide.
2. Crimp and fasten the fabric to the sheet metal with screws 50 mm (2 inches) on center. The fabric shall not be stressed, except by the air pressure.

I. Exhaust System Insulation:
1. Adhesive and insulation materials shall be applied on clean, dry surfaces from which loose scale and construction debris has been removed by wire brushing.
2. Fill all cracks, voids, and joints of applied insulation material with high temperature 1093 °C (2000 °F) insulating cement before applying the outer covering.
3. The installation shall be clean and free of debris, thermally and structurally tight without sag, neatly finished at all hangers or other penetrations, and shall provide a smooth finished surface.
4. Insulation and jacket shall terminate hard and tight at all anchor points.
5. Insulate completely from engine exhaust flexible connection through roof or wall construction, including muffler.

3.2 ACCEPTANCE CHECKS AND TESTS

A. Provide the services of a factory-authorized, factory-trained representative of the engine generator manufacturer to inspect field-assembled components and equipment installation, and to supervise the field tests.

B. When the complete engine generator system has been installed and prior to the final inspection, test all components of the system in the presence of the COR for proper operation of the individual components and the complete system and to eliminate electrical and mechanical defects.

C. Furnish fuel oil, lubricating oil, anti-freeze liquid, water treatment, rust-inhibitor, and load bank for testing of the engine generator.

D. Visual Inspection: Visually verify proper installation of engine generator and all components per manufacturer’s pre-functional installation checklist.

E. Set engine generator circuit breaker protective functions per Section 26 05 73, OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY.

F. Field Tests:

1. Perform manufacturer’s after-starting checks and inspections.
2. Test the engine generator for six hours of continuous operation as follows:
   a. Two hours while delivering 100% of the specified kW.
   b. Four hours while the engine generator is delivering 80% of its specified kW rating.
   c. If during the 6-hour continuous test, an engine generator failure occurs or the engine generator cannot maintain specified power output, the test(s) are null and void. After repair and/or adjustments, the test(s) shall be repeated at no additional cost to the Government until satisfactory results are attained.
3. Record the following test data at 30-minute intervals:
   a. Time of day, as well as reading of running time indicator.
   b. kW.
   c. Voltage on each phase.
   d. Amperes on each phase.
   e. Engine RPM.
   f. Frequency.
   g. Coolant water temperature.

h. Fuel pressure.

i. Oil pressure.

j. Outdoor temperature.

k. Average ambient temperature in the vicinity of the engine generator.

4. Demonstrate that the engine generator will attain proper voltage and frequency within the specified time limit from a cold start after the closing of a single contact.

5. Furnish a resistance-type load for the testing of the engine generator. Test loads shall always include adequate resistance to assure stability of the loads and equipment during all of the testing operations. The test load kW rating shall not be less than 100% of the specified kW rating of the engine generator.

G. Starting System Test:

1. Demonstrate that the batteries and cranking motor are capable of five starting attempts of 10 seconds cranking each at 10-second intervals with the battery charger turned off.

H. Remote Annunciator Panel and Remote Manual Stop Tests:
Simulate conditions to verify proper operation of each visual or audible indication, interconnecting hardware and software, and reset button. Simulate emergency stop of the generator by initiating the remote manual stop station, while the generator is in operation.

I. Fuel systems shall be flushed and tested per Section 23 10 00, FACILITY FUEL SYSTEMS: Fuel supply and storage requirements.

J. Automatic Operation Tests:
Test the engine generator and associated automatic transfer switches to demonstrate automatic starting, loading and unloading. The load for this test shall be the actual connected loads. Initiate loss of normal source and verify the specified sequence of operation. Restore the normal power source and verify the specified sequence of operation. Verify resetting of controls to normal.

K. Parallel Operation Test:

1. Test the capability of each engine generator to parallel and share load with other engine generators, individually and in all combinations. During operations, record load-sharing characteristics of each engine generator in parallel operation. Provide multiple load banks as required. Record the following data:

a. Ambient temperature (at 15-minute intervals).
b. Generator output current (before and after load changes).
c. Generator output voltage (before and after load changes).
d. Power division and exchange between engine generators.
e. Real power (watts) and reactive power (vars) on each engine generator.

2. Connect each engine generator, while operating at no load, in parallel with one other engine generator in the system, operating at rated kW, until all possible two-unit-in-parallel combinations have been tested. Verify stabilization of voltage and frequency within specified bandwidths and proportional sharing of real and reactive loads. Document stabilization of voltage, frequency within specified bandwidth, the active power division, active power exchange, reactive power division, voltage and frequency stability, and transient response in the following steps for each combination.
   a. Divide the load proportionally between the engine generators and operate in parallel for 15 minutes.
   b. Increase the load in steps until each engine generator is loaded to its service load.
   c. Decrease the load in steps until each engine generator is loaded to approximately 25% of its rated kW.
   d. Increase the load in steps until each engine generator is loaded to approximately 50% of its rated kW. Verify stabilization of voltage and frequency within specified bandwidths and proportional sharing of real and reactive load.
   e. Reduce the sum of the loads on all engine generators to the rated kW of one engine generator.
   f. Transfer a load equal to the rated kW of one engine generator to and from each engine generator. Verify stabilization of voltage and frequency within specified bandwidths and proportional sharing of real and reactive load.
3. Connect each engine generator, while operating at no load, in parallel with all multiple combinations of all other engine generators in the system, while operating at rated kW, until all multiple combinations of parallel operations have been achieved.

L. At the completion of the field tests, fill the main storage tank and day tank with fuel of grade and quality as recommended by the

manufacturer of the engine. Fill all engine fluids to levels as recommended by manufacturer.

M. When any defects are detected during the tests, correct all the deficiencies and repeat all or part of the 6-hour continuous test as requested by theCOR, at no additional cost to the Government.

N. Provide test and inspection results in writing to the COR.

3.3 FOLLOW-UP VERIFICATION

A. After completion of acceptance checks, settings, and tests, the Contractor shall demonstrate that the engine generator(s) and control and annunciation components are in good operating condition and properly performing the intended function.

3.4 INSTRUCTIONS AND FINAL INSPECTIONS

A. Laminate or mount under acrylic resin a set of operating instructions for the system and install instructions within a frame mounted on the wall near the engine generator at a location per the COR.

B. Furnish the services of a competent and factory-trained technician for one 4-hour period for instructions to VA personnel in operation and maintenance of the equipment, on the date requested by the COR.

---END---

SECTION 26 33 53
STATIC UNINTERRUPTIBLE POWER SUPPLY

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, installation, connection, and testing of the static uninterruptible power supply, indicated in this section as UPS.

1.2 RELATED WORK

A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.

B. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Low-voltage conductors.

C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible fault currents.

D. Section 26 05 33, RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS: Conduits.

E. Section 26 05 73, OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY: Short circuit and coordination study, and requirements for a coordinated electrical system.

F. Section 26 24 13, DISTRIBUTION SWITCHBOARDS: For low-voltage switchboard required for maintenance bypass of multiple module UPS.

1.3 QUALITY ASSURANCE

A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 FACTORY TESTS

A. UPS shall be thoroughly tested at the factory to assure that there are no electrical or mechanical defects.

B. Factory Tests shall be in accordance with Paragraph, MANUFACTURED PRODUCTS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:

1. UPS shall be factory full-load tested to meet the requirements specified using a test battery (not the battery to be supplied with the system) with AC input power and with battery power for a minimum of 8 hours, with meter readings taken every 30 minutes. Should a malfunction occur, the problem shall be corrected and the test shall be repeated. The tests shall encompass all aspects of operation,

such as module failure, static bypass operation, battery failure, input power failure and overload ratings.

1.5 SUBMITTALS

A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:

1. Shop Drawings:
   a. Submit sufficient information to demonstrate compliance with drawings and specifications.
   b. Include electrical ratings, dimensions, mounting details, materials, required clearances, terminations, weight, plan, front, side, and rear elevations, accessories, and device nameplate data.
   c. Provide detailed and project-specific system diagram, showing maintenance bypass, UPS module(s), battery cabinet(s) and batteries, major circuit protective devices, interconnecting power and control wiring, key-type mechanical interlocks, and connections to power sources and loads, as applicable. Indicate whether interconnections are factory-provided/factory-installed, factory-provided/field-installed, or field-provided/field installed.

2. Manuals:
   a. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals including technical data sheets, wiring diagrams, and information for ordering replacement parts.
      1) Wiring diagrams shall have their terminals identified to facilitate installation, maintenance, and operation.
      2) Wiring diagrams shall indicate internal wiring for each item of equipment and the interconnection between the items of equipment.
      3) Provide a clear and concise description of operation, which gives, in detail, the information required to properly operate the UPS, including but not limited to bypass switchboard, UPS, key-type mechanical interlocks, remote devices, emergency power off buttons, fire alarm interface, and other components as applicable.

b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
   1) Include complete "As Installed" diagrams that indicate all pieces of equipment and their interconnecting wiring.
   2) Include complete diagrams of the internal wiring for each piece of equipment, including "As Installed" revisions of the diagrams.
   3) The wiring diagrams shall identify the terminals to facilitate installation, maintenance, operation, and testing.

3. Test Reports:
   a. Submit certified factory design and production test reports for approval.
   b. Two weeks prior to the final inspection, submit certified field test reports and data sheets to the COR.
4. Certifications: Two weeks prior to final inspection, submit the following.
   a. Certification by the manufacturer that the UPS conforms to the requirements of the drawings and specifications.
   b. Certification by the Contractor that the UPS has been properly installed, adjusted, and tested.

1.6 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata), form a part of this specification to the extent referenced. Publications are referenced in the text by basic designation only.

B. Institute of Engineering and Electronic Engineers (IEEE):

C57.110-08.....Recommended Practice for Establishing Transformer Capability When Supplying Nonsinusoidal Load Currents

C62.41.1-02.....Surge Environment in Low-Voltage (1000 V and Less) AC Power Circuits

C62.41.2-02.....Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

450-20.....Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications

485-20.....Sizing Lead-Acid Batteries for Stationary Applications

C. International Code Council (ICC):

IBC-18.....International Building Code

D. National Electrical Manufacturers Association (NEMA):

PE 1-12.....Uninterruptible Power Systems - Specification and Performance Verification

E. National Fire Protection Association (NFPA):

70-23.....National Electrical Code (NEC)

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. System Capacity: Unless stated otherwise, the parameters listed are under full rated output load at a minimum of 0.9 power factor, with batteries fully charged and floating on the DC bus and with nominal input voltage. Overall 80kVA, N+1redundant, at 40 °C.

B. Battery Capacity: Discharge time to end voltage: 15 minutes, at 25 °C (77 °F). Battery shall be capable of delivering 125 percent of full rated output load at initial start-up.

C. System Bus Bracing: Braced for amperes symmetrical interrupting capacity as shown on drawings.

D. AC Input:

1. Voltage 208 volts line-to-line.
2. Number of phases: 3-phase, 3-wire, plus ground.
3. Voltage Range: Plus 10 percent, minus 15 percent, without affecting battery float voltage or output voltage.
4. Frequency: 60 Hz, plus or minus 5 percent.
5. Total harmonic current distortion (THD) reflected into the primary line: 10 percent maximum.

E. AC Output

1. Voltage 208/ volts line-to-line, 120 volts line-to-neutral.
2. Number of phases: 3-phase, 4-wire, plus ground.
3. Voltage regulation:
   a. Balanced load: Plus or minus 1.0 percent.
   b. 100 percent load imbalance, phase-to-phase: Plus or minus 3 percent.
4. Frequency: 60 Hz.
5. Frequency regulation: Plus or minus 0.05 percent.
6. Harmonic content (RMS voltage): 5 percent maximum total harmonic distortion with 100% nonlinear load.

7. Load power factor operating range: 1.0 to 0.8 lagging.
8. Phase displacement:
   a. Balanced load: Plus or minus 1 degree of bypass input.
9. Overload capability (at full voltage) (excluding battery):
   a. 125 percent load for 10 minutes.
   b. 150 percent load for 1 minute.

F. Voltage Transient Response:
   1. 100 percent load step: Plus or minus 5 percent.

2.2 UPS

A. General Description: UPS module shall consist of a rectifier/charger unit and a 3-phase inverter module unit with their associated transformers, synchronizing equipment, input and output circuit breakers, and accessories as required for operation.

B. Rectifier/Charger Unit: Rectifier/charger unit shall be solid state and shall provide direct current to the DC bus.
   1. Input Circuit Breaker: Rectifier/charger unit shall be provided with an input circuit breaker. The circuit breaker shall be sized to accept simultaneously the full-rated load and the battery recharge current.
   2. Sizing: Rectifier/charger unit shall be sized for the following two simultaneous operating conditions:
      a. Supplying the full rated load current to the inverter.
      b. Recharging a fully-discharged battery to 95 percent of rated ampere-hour capacity within ten times the discharge time after normal AC power is restored, with the input protective device closed.

C. Inverter Unit: Inverter unit shall be a solid-state device capable of accepting power from the DC bus and providing AC power within specified limits.
   1. Output Overload: The inverter shall be able to sustain an overload as specified across its output terminals.
   2. Synchronism: The inverter shall normally operate in phase-lock and synchronism with the bypass source.
   3. Modular Construction: Each control logic printed circuit board shall be electrically and physically packaged on an individual plug-in module with separate indication and adjustments.
   4. Output Circuit Breaker: The output circuit breaker shall be capable of shunt tripping and shall have interrupting capacity as specified.

Circuit breaker shall have provision for locking in the "off" position.

5. Output Transformer: The inverter output transformer shall be similar to the input transformer and shall be capable of handling up to K-13 nonlinear loads as described in IEEE C57.110.

6. Modular Inverter Isolation: Each inverter in the UPS shall have fault sensing and static isolation as well as an output protective device, to remove a faulted module from the system without affecting the critical load bus beyond the stated limits. The protection system shall have control logic capable of isolating only the faulted module, and shall not shut down the entire UPS upon a fault in one module. Open protective devices shall be indicated by an alarm and indicator light.

D. External Protection: UPS module shall have built-in self-protection against undervoltage, overvoltage, overcurrent and surges introduced on the AC input source and/or the bypass source. The UPS system shall sustain input surges without damage in accordance with IEEE C62.41.1 and IEEE C62.41.2. The UPS shall also have built-in self-protection against overvoltage and voltage surges introduced at the output terminals by paralleled sources, load switching, or circuit breaker operation in the critical load distribution system.

E. Internal Protection: UPS module shall be self-protected against overcurrent, sudden changes in output load and short circuits at the output terminals. UPS module shall be provided with output reverse power detection which shall cause that module to be disconnected from the critical load bus when output reverse power is present. UPS module shall have built-in protection against permanent damage to itself and the connected load for predictable types of failure within itself and the connected load. At the end of battery discharge limit, the module shall shut down without damage to internal components.

2.3 STATIC BYPASS TRANSFER SWITCH

A. A static bypass transfer switch shall be provided as an integral part of the UPS and shall consist of a static switch and a bypass protective device or bypass switch. The control logic shall contain an automatic transfer circuit that senses the status of the inverter logic signals and alarm conditions and provides an uninterrupted transfer of the load

to the bypass AC power source, without exceeding the transient limits specified herein, when a malfunction occurs in the UPS or when an external overload condition occurs.

1. Static Bypass Transfer Switch Disconnect: A disconnect shall be incorporated to isolate the static bypass transfer switch assembly so it can be removed for servicing. The disconnect shall be equipped with auxiliary contacts and provision for padlocking in either the "on" or "off" position.

2.4 MAINTENANCE BYPASS – MULTIPLE-MODULE UPS

A. A maintenance bypass switchboard shall be provided. At the minimum, the bypass switchboard enclosure, bussing, and circuit breakers shall meet the requirements of Section 26 24 13, DISTRIBUTION SWITCHBOARDS. Additionally, the bypass switchboard shall contain key-type mechanical interlocks, control wiring, and accessories as needed for proper operation with the UPS. The maintenance bypass switchboard shall provide the capability to continuously support the load from the bypass AC power source while the UPS is isolated for maintenance.

B. The maintenance bypass switch shall provide the capability of transferring the load from the UPS static bypass transfer switch to maintenance bypass and then back to the UPS static bypass transfer switch with no interruption to the load.

2.5 SYSTEM CONTROL CABINET – MULTI-MODULE UPS

A. The UPS shall be provided with a LCD control/indicator panel. Meters, controls, alarms, system diagnostics, mimic screen showing one-line diagram of the system, and indicators for operation of the UPS shall be on this panel. The system control cabinet shall communicate with each UPS module, the static bypass transfer switch and its bypass disconnect, the UPS input and output circuit breakers, and the UPS maintenance bypass switchboard.

1. Module Meters:
   a. Meters shall have 1 percent accuracy.
   b. The following functions shall be monitored and displayed:
      1) Input voltage, phase-to-phase (all three phases).
      2) Input current, all three phases.
      3) Input frequency.

4) Battery voltage.
5) Battery current (charge/discharge).
6) Output voltage, phase-to-phase and phase-to-neutral (all three phases).
7) Output current, all three phases.
8) Output frequency.
9) Output kilowatts.
10) Elapsed time meter to indicate hours of operation, 6 digits.
11) Bypass voltage, phase-to-phase and phase-to-neutral (all three phases).
12) Output kilovars.
13) Output kilowatt hours, with 15-minute interval.

2. Module Controls:
   a. Module shall have the following controls:
      1) Alarm test/reset function.
      2) Module input protective device trip function.
      3) Module output protective device trip function.
      4) Battery protective device trip function.
      5) Emergency Power Off (EPO) pushbutton, with guard.
      6) Control power off switch.
      7) Static bypass transfer switch enable/disable selector switch.
3. Module Alarm Indicators:
   a. Module shall have indicators for the following alarm items. Any one of these conditions shall turn on an audible alarm and the appropriate summary indicator. Each new alarm shall register without affecting any previous alarm.
      1) Input AC power source failure.
      2) Input protective device open.
      3) Output protective device open.
      4) Overload.
      5) Overload shutdown.
      6) DC overvoltage.
      7) DC ground fault.
      8) Low battery.
      9) Battery discharged.
      10) Battery protective device open.
      11) Cooling fan failure.
      12) Equipment overtemperature.

13) Control power failure.
14) Charger off.
15) Inverter off.
16) Emergency off.
17) UPS on battery.
18) Load on static bypass.
19) Static bypass transfer switch disabled.
20) Inverter output overvoltage, undervoltage, overfrequency, and underfrequency.
21) Bypass source overvoltage, undervoltage, overfrequency, and underfrequency.
22) Bypass source to inverter out of synchronization.

D. Any single indicator shall also turn on the audible alarm. An audible alarm test/reset button and lamp test/reset button shall be included. This reset button shall not affect nor reset the alarm on the module control panel

2.9 BATTERY SYSTEM

A. General: A storage battery with sufficient ampere-hour rating to maintain UPS output at full capacity for the specified duration shall be provided for each UPS module.
B. Battery Type: Lead calcium.
C. Battery Construction: The battery shall be of the valve-regulated, sealed, non-gassing, recombinant type.

D. Battery Cabinet: The batteries shall be furnished in a battery cabinet matching the UPS. The battery cabinet shall be provided with smoke and high temperature alarms.
F. Battery Cables: Battery-to-battery connections shall be stranded cable with proper cable supports.
G. Battery Disconnect: Each battery cabinet or rack shall have a fused disconnect switch or circuit breaker, lockable in the “off” position, provided in a NEMA 1 enclosure.

PART 3 - EXECUTION

3.1 INSTALLATION

A. The UPS shall be set in place, wired, and connected in accordance with the approved shop drawings and manufacturer's instructions.

3.2 ACCEPTANCE CHECKS AND TESTS

A. An authorized representative of the UPS manufacturer shall technically supervise and participate during all of the field adjustments and tests. Major adjustments and field tests shall be witnessed by the COR. The manufacturer’s representative shall certify in writing that the equipment has been installed, adjusted, and tested in accordance with the manufacturer’s recommendations.

B. Perform manufacturer’s required field tests in accordance with the manufacturer's recommendations. In addition, include the following:

1. Visual Inspection and Tests:
   a. Compare equipment nameplate data with specifications and approved shop drawings.
   b. Inspect physical, electrical, and mechanical condition.
   c. Verify appropriate anchorage, required area clearances, and correct alignment.
   d. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey after energization.
   e. Verify grounding connections.
   f. Vacuum-clean enclosure interior. Clean enclosure exterior.
   g. Verify the correct operation of all alarms and indicating devices.
   h. Attach a phase rotation meter to the UPS input, output, and bypass buses, and observe proper phase sequences.
   i. Check and test controls for proper operation.
   j. Check doors for proper alignment and operation.
   k. Check and test each protective device for proper mechanical and electrical operation.
   l. Verify protective device overcurrent trip settings against approved coordination study.
2. Load Test: The UPS shall be load tested for a continuous 24 hour period by means of resistive load banks, sized for full rated output load and provided by the UPS manufacturer. The UPS shall be continuously tested at 1/2 load for 8 hours, 3/4 load for 8 hours and full load for 8 hours. If a failure occurs during the burn-in period, the tests shall be repeated. Instrument readings shall be recorded every half hour for the following:

a. Input voltage and current (all three phases, for each module).
b. Input and output frequency.
c. Battery voltage for each module.
d. Output voltage and current (all three phases, for each module).
e. Output kilowatts for each module.
f. Output voltage and current (all three phases).
g. Output kilowatts.

3. Full Load Burn In Test: The UPS shall undergo an additional full load burn-in period of 24 continuous hours by means of resistive load banks, sized for full rated output load and provided by the UPS manufacturer. If a failure occurs during the burn-in period, the tests shall be repeated. Instrument readings shall be recorded every half hour as above. The following tests shall be performed:
   a. With the UPS carrying full rated output load and supplied from the normal source, switch 100 percent of load bank capacity on and off a minimum of five times within the burn-in period.
   b. With the UPS carrying maximum continuous design load and supplied from the emergency source, repeat the switching operations described above.
4. Full Load Battery Burn In Test: The UPS shall undergo a full load battery test by means of resistive load banks, sized for full rated output load and provided by the UPS manufacturer. If a failure occurs during the battery discharge time, the tests shall be repeated. Instrument readings shall be recorded every half hour as above.
   a. With the UPS carrying full rated output load and operating on battery power, switch 100 percent of load bank capacity on and off a minimum of five times within the battery discharge time.
5. Battery Discharge and Recharge Test: With the battery fully charged, the UPS shall undergo a complete battery discharge test to full depletion followed by a full recharge. Instrument readings shall be recorded every minute during discharge for the following:
   a. Battery voltage and current..
   b. Output voltage and current (all three phases).
   c. Output kilowatts.
   d. Output voltage and current (all three phases).
   e. Output kilowatts (system).

f. Output frequency.

3.3 FOLLOW-UP VERIFICATION

A. After completion of acceptance checks and tests, the Contractor shall show by demonstration in service that the UPS is in good operating condition and properly performing the intended function.

3.4 ONE LINE DIAGRAM AND SEQUENCE OF OPERATION

A. At final inspection, an as-built one line diagram shall be laminated or mounted under acrylic glass, and installed in a frame mounted near the UPS.

B. Furnish a written sequence of operation for the UPS and connected line side/load side electrical distribution equipment. The sequence of operation shall be laminated or mounted under acrylic glass, and installed in a frame mounted near the UPS.

C. Deliver an additional four copies of the as-built one line diagram and sequence of operation to the COR.

3.5 INSTRUCTION

A. Furnish the services of a factory-trained technician for one 4-hour training period for instructing personnel in the maintenance and operation of the UPS, on the dates requested by the COR.

---END---

SECTION 26 36 23
AUTOMATIC TRANSFER SWITCHES

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, installation, connection, and testing of open-transition automatic transfer switches with bypass isolation, indicated as automatic transfer switches or ATS in this section.

1.2 RELATED WORK

A. Section 03 30 00, CAST-IN-PLACE CONCRETE: Requirements for concrete equipment pads.

B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.

C. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Low-voltage conductors.

D. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personal safety and to provide a low impedance path for possible ground fault currents.

E. Section 26 05 33, RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS: Conduits.

F. Section 26 05 73, OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY: Short circuit and coordination study, and requirements for a coordinated electrical system.

G. Section 26 32 13, ENGINE-GENERATORS: Requirements for normal and emergency power generation.

H. Section 27 05 11, REQUIREMENTS FOR COMMUNICATIONS INSTALLATIONS: General communications requirements that are common to more than one section in Division 27.

I. Section 27 05 33, CONDUITS AND BACKBOXES FOR COMMUNICATION SYSTEMS: Raceways for communications cabling.

1.3 QUALITY ASSURANCE

A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

B. A factory-authorized representative shall be capable of providing emergency maintenance and repairs at the project site within 4 hours maximum of notification.

C. Automatic transfer switch, bypass/isolation switch, and annunciation control panels shall be products of the same manufacturer.

1.4 FACTORY TESTS

A. ATS shall be thoroughly tested at the factory to ensure that there are no electrical or mechanical defects.

B. Factory Tests shall be in accordance with Paragraph, MANUFACTURED PRODUCTS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:

1. Perform visual inspection to verify that each ATS is as specified.
2. Perform mechanical test to verify that ATS sections are free of mechanical defects.
3. Perform insulation resistance test to ensure electrical integrity and continuity of entire system.
4. Perform main switch contact resistance test.
5. Perform electrical tests to verify complete system electrical operation.

1.5 SUBMITTALS

A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:

1. Shop Drawings:
   a. Submit sufficient information to demonstrate compliance with drawings and specifications.
   b. Include voltage rating, continuous current rating, number of phases, withstand and closing rating, dimensions, weights, mounting details, conduit entry provisions, front view, side view, equipment and device arrangement, elementary and interconnection wiring diagrams, factory relay settings, and accessories.
   c. For automatic transfer switches that are networked together to a common means of annunciation and/or control, submit interconnection diagrams as well as site and building plans, showing connections for normal and emergency sources of power, load, control and annunciation components, and interconnecting communications paths. Equipment locations on the diagrams and plans shall match the site, building, and room designations on the drawings.

d. Complete nameplate data, including manufacturer's name and catalog number.
e. A copy of the markings that are to appear on the automatic transfer switches when installed.

2. Manuals:
   a. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals, including technical data sheets, wiring diagrams, and information for ordering replacement parts.
      1) Schematic signal and control diagrams, with all terminals identified, matching terminal identification in the automatic transfer switches.
      2) Include information for testing, repair, troubleshooting, assembly, disassembly, and factory recommended/required periodic maintenance procedures and frequency.
      3) Provide a replacement and spare parts list. Include a list of tools and instruments for testing and maintenance purposes.
   b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
      1) Include complete "As Installed" diagrams that indicate all pieces of equipment and their interconnecting wiring.
      2) Include complete diagrams of the internal wiring for each piece of equipment, including "As Installed" revisions of the diagrams.
      3) The wiring diagrams shall identify the terminals to facilitate installation, maintenance, operation, and testing.
3. Certifications:
   a. When submitting the shop drawings, submit a certified test report from a recognized independent testing laboratory that a representative sample has passed UL 1008 prototype testing.
   b. Two weeks prior to final inspection, submit the following.
      1) Certification by the manufacturer that the ATS conform to the requirements of the drawings and specifications.
      2) Certification by the Contractor that transfer switches have been properly installed, adjusted, and tested.

1.6 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

B. Institute of Electrical and Electronic Engineers (IEEE):

446-95.....Emergency and Standby Power Systems for Industrial and Commercial Applications

C37.90.1-12.....Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus

C62.41.1-02.....Guide on the Surges Environment in Low-Voltage (1000 V and Less) AC Power Circuits

C62.41.2-02.....Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

C. International Code Council (ICC):

IBC-18.....International Building Code

D. National Electrical Manufacturers Association (NEMA):

250-20.....Enclosures for Electrical Equipment (1000 Volts Maximum)

ICS 6-93.....Enclosures

ICS 4-15.....Application Guideline for Terminal Blocks

MG 1-21.....Motors and Generators

E. National Fire Protection Association (NFPA):

70-23.....National Electrical Code (NEC)

99-21.....Health Care Facilities

110-22.....Emergency and Standby Power Systems

F. Underwriters Laboratories, Inc. (UL):

50-15.....Enclosures for Electrical Equipment

508-18.....Industrial Control Equipment

891-19.....Switchboards

1008-14.....Transfer Switch Equipment

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Automatic transfer switches shall comply with IEEE, NEMA, NFPA, UL, and have the following features:

1. Automatic transfer switches shall be open transition switches, 4-pole, draw-out construction, electrically operated, mechanically held open contact type, without integral overcurrent protection. Automatic transfer switches utilizing automatic or non-automatic molded case circuit breakers, insulated case circuit breakers, or power circuit breakers as switching mechanisms are not acceptable.
2. Automatic transfer switches shall be completely factory-assembled and wired such that only external circuit connections are required in the field.
3. Each automatic transfer switch shall be equipped with an integral bypass/isolation switch.
4. Ratings:
   a. Phases, voltage, continuous current, poles, and withstand and closing ratings shall be as shown on the drawings.
   b. Transfer switches are to be rated for continuous duty at specified continuous current rating on 60Hz systems.
   c. Maximum automatic transfer switch rating: 800 A.
5. Markings:
   a. Markings shall be in accordance with UL 1008.
6. Tests:
   a. Automatic transfer switches shall be tested in accordance with UL 1008. The contacts of the transfer switch shall not weld during the performance of withstand and closing tests when used with the upstream overcurrent device and available fault current specified.

7. Surge Withstand Test:
   a. Automatic transfer switches utilizing solid-state devices in sensing, relaying, operating, or communication equipment or circuits shall comply with IEEE C37.90.1.
8. Housing:
   a. Enclose automatic transfer switches in wall- or floor-mounted steel cabinets, with metal gauge not less than No. 14, in accordance with UL 508, or in a switchboard assembly in accordance with UL 891, as shown on the drawings.
   b. Enclosure shall be constructed so that personnel are protected from energized bypass-isolation components during automatic transfer switch maintenance.

c. Automatic transfer switch components shall be removable without disconnecting external source or load power conductors.
d. Finish: Cabinets shall be given a phosphate treatment, painted with rust-inhibiting primer, and finish-painted with the manufacturer's standard enamel or lacquer finish.
e. Viewing Ports: Provide viewing ports so that contacts may be inspected without disassembly.

9. Operating Mechanism:
   a. Actuated by an electrical operator.
   b. Electrically and mechanically interlocked so that the main contact cannot be closed simultaneously in either normal and emergency position.
   c. Normal and emergency main contacts shall be mechanically locked in position by the operating linkage upon completion of transfer. Release of the locking mechanism shall be possible only by normal operating action.
   d. Contact transfer time shall not exceed six cycles.
   e. Operating mechanism components and mechanical interlocks shall be insulated or grounded.
10. Contacts:
   a. Main contacts: Silver alloy.
   b. Neutral contacts: Silver alloy, with continuous current rating not less than twice the rating of the phase contacts.
   c. Current carrying capacity of arcing contacts shall not be used in the determination of the automatic transfer switch rating, and shall be separate from the main contacts.
   d. Main and arcing contacts shall be visible for inspection with cabinet door open and barrier covers removed.
11. Manual Operator:
   a. Capable of operation by one person in either direction under no load.
12. Replaceable Parts:
   a. Include the main and arcing contacts individually or as units, as well as relays, and control devices.
   b. Automatic transfer switch contacts and accessories shall be replaceable from the front without removing the switch from the cabinet and without removing main conductors.
13. Sensing Features:

a. Undervoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100% of nominal, and dropout voltage is adjustable from 75 to 98% of pickup value. Factory set for pickup at 90% and dropout at 85%.
b. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals. Adjustable from zero to six seconds, and factory set for one second.
c. Voltage/Frequency Lockout Relay: Prevent premature transfer to the engine-generator. Pickup voltage shall be adjustable from 85 to 100% of nominal. Factory set for pickup at 90%. Pickup frequency shall be adjustable from 90 to 100% of nominal. Factory set for pickup at 95%.
d. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes, and factory set for 10 minutes to automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
e. Test Switch: Simulate normal-source failure.
f. Switch-Position Indication: Indicate source to which load is connected.
g. Source-Available Indication: Supervise sources via transfer switch normal- and emergency-source sensing circuits.
h. Normal Power Indication: Indicate "Normal Source Available."
i. Emergency Power Indication: Indicate "Emergency Source Available."
j. Transfer Override Control: Overrides automatic retransfer control so that automatic transfer switch shall remain connected to emergency power source regardless of condition of normal source. Control panel shall indicate override status.
k. Engine Starting Contacts: One isolated and normally closed and one isolated and normally open; rated 5 A at 30 V DC minimum.
l. Engine Shutdown Contacts: Time delay adjustable from zero to 15 minutes, and factory set for 5 minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
m. Engine-Generator Exerciser: Programmable exerciser starts engine-generator(s) and transfers load to them from normal source for a preset time, then retransfers and shuts down engine-generator(s)

after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods are adjustable from 10 to 30 minutes. Factory settings shall be for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period.

14. Controls:
    a. Controls shall provide indication of switch status and be equipped with alarm diagnostics.
    b. Controls shall control operation of the automatic transfer switches.
15. Factory Wiring: Train and bundle factory wiring and label either by color-code or by numbered/lettered wire markers. Labels shall match those on the shop drawings.
16. Annunciation, Control, and Programming Interface Components: Devices for communicating with remote programming devices, annunciators, or control panels shall have open-protocol communication capability matched with remote device.
17. Provide IR inspection windows to provide visibility connection.
18. Switch shall provide 3Ph Load monitoring either by an external ammeter or through the control panel.

2.2 SEQUENCE OF OPERATION

A. The specified voltage decrease in one or more phases of the normal power source shall initiate the transfer sequence. The automatic transfer switch shall start the engine-generator(s) after a specified time delay to permit override of momentary dips in the normal power source.

B. The automatic transfer switch shall transfer the load from normal to emergency source when the frequency and voltage of the engine-generator(s) have attained the specified percent of rated value.

C. Engine Start: A voltage decrease, at any automatic transfer switch, in one or more phases of the normal power source to less than the specified value of normal shall start the engine-generator(s) after a specified time delay.

D. Transfer to Emergency System Loads: Automatic transfer switches for Emergency System loads shall transfer their loads from normal to emergency source when frequency and voltage of the engine-generator(s)

have attained the specified percent of rated value. Only those switches with deficient normal source voltage shall transfer.

E. Transfer to Equipment Branch Loads: Automatic transfer switches for Equipment Branch loads shall transfer their loads to the engine-generator on a time-delayed, staggered basis, after the Emergency System switches have transferred. Only those switches with deficient normal source voltage shall transfer.

F. Retransfer to Normal (All Loads): Automatic transfer switches shall retransfer the load from emergency to normal source upon restoration of normal supply in all phases to the specified percent or more of normal voltage, and after a specified time delay. Should the emergency source fail during this time, the automatic transfer switches shall immediately transfer to the normal source whenever it becomes available. After restoring to normal source, the engine-generator(s) shall continue to run unloaded for a specified interval before shut-down.

2.3 BYPASS-ISOLATION SWITCH

A. Provide each automatic transfer switch with two-way bypass-isolation manual type switch. The bypass-isolation switch shall permit load by-pass to either normal or emergency power source and complete isolation of the automatic transfer switch, independent of transfer switch position. Bypass and isolation shall be possible under all conditions including when the automatic transfer switch is removed from service.

B. Operation: The bypass-isolation switch shall have provisions for operation by one person through the movement of a maximum of two handles at a common dead front panel in no more than 15 seconds. Provide a lock, which must energize to unlock the bypass switch, to prevent bypassing to a dead source. Provide means to prevent simultaneous connection between normal and emergency sources.

1. Bypass to normal (or emergency): Operation of bypass handle shall allow direct connection of the load to the normal (or emergency) source, without load interruption or by using a break-before-make design, or provide separate load interrupter contacts to momentarily interrupt the load.
   a. Ensure continuity of auxiliary circuits necessary for proper operation of the system.
   b. A red indicating lamp shall light when the automatic transfer switch is bypassed.

c. Bypassing source to source: If the power source is lost while in the bypass position, bypass to the alternate source shall be achievable without re-energization of the automatic transfer switch service and load connections.

2. Isolation: Operation of the isolating handle shall isolate all live power conductors to the automatic transfer switch without interruption of the load.
   a. Interlocking: Provide interlocking as part of the bypass-isolation switch to eliminate personnel-controlled sequence of operation, and to prevent operation to the isolation position until the bypass function has been completed.
   b. Padlocking: Include provisions to padlock the isolating handle in the isolated position.
   c. Visual verification: The isolation blades shall be visible in the isolated position.
3. Testing: It shall be possible to test (normal electrical operation) the automatic transfer switch and engine-generator(s) with the isolation contacts closed and the load bypassed without interruption of power to the load.

C. Ratings: The electrical capabilities and ratings of the bypass-isolation switch shall be compatible with those of the associated automatic transfer switch, including any required additional withstand tests.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install automatic transfer switches and associated remote components in accordance with the NEC, as shown on the drawings, and manufacturer’s instructions.

B. Anchor automatic transfer switches with rustproof bolts, nuts, and washers not less than 12 mm (1/2 inch) diameter, in accordance with manufacturer’s instructions, and as shown on drawings.

D. Mount automatic transfer switches on concrete slab. Unless otherwise indicated, the slab shall be at least 100 mm (4 inches) thick. The top of the concrete slab shall be approximately 100 mm (4 inches) above finished floor. Edges above floor shall have 12.5 mm (1/2 inch) chamfer. The slab shall be of adequate size to project at least 100 mm

(8 inches) beyond the equipment. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 75 mm (3 inches) above slab surface. Concrete work shall be as specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.

3.2 ACCEPTANCE CHECKS AND TESTS

A. An authorized representative of the automatic transfer switch manufacturer shall technically supervise and participate during all of the field adjustments and tests. Major adjustments and field tests shall be witnessed by the COR. The manufacturer’s representative shall certify in writing that the equipment has been installed, adjusted and tested in accordance with the manufacturer’s recommendations.

B. Perform manufacturer’s required field tests in accordance with the manufacturer's recommendations. In addition, include the following:

1. Visual Inspection and Tests:
   a. Compare equipment nameplate data with specifications and approved shop drawings.
   b. Inspect physical, electrical, and mechanical condition.
   c. Confirm correct application of manufacturer's recommended lubricants.
   d. Verify appropriate anchorage, required area clearances, and correct alignment.
   e. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey after energization.
   f. Verify grounding connections.
   g. Verify ratings of sensors.
   h. Vacuum-clean enclosure interior. Clean enclosure exterior.
   i. Exercise all active components.
   j. Verify that manual transfer warning signs are properly placed.
   k. Verify the correct operation of all sensing devices, alarms, and indicating devices.
2. Electrical tests:
   a. Perform insulation-resistance tests.

b. After energizing circuits, demonstrate the interlocking sequence and operational function for each automatic transfer switch at least three times.
   1) Test bypass-isolation unit functional modes and related automatic transfer switch operations.
   2) Power failure of normal source shall be simulated by opening upstream protective device. This test shall be performed a minimum of five times.
   3) Power failure of emergency source with normal source available shall be simulated by opening upstream protective device for emergency source. This test shall be performed a minimum of five times.
   4) Low phase-to-ground voltage shall be simulated for each phase of normal source.
   5) Operation and settings shall be verified for specified automatic transfer switch operational feature, such as override time delay, transfer time delay, return time delay, engine shutdown time delay, exerciser, auxiliary contacts, and supplemental features.
   6) Verify pickup and dropout voltages by data readout or inspection of control settings.
   7) Verify that bypass and isolation functions perform correctly, including the physical removal of the automatic transfer switch while in bypass mode.

c. Ground-fault tests: Verify that operation of automatic transfer switches shall not cause nuisance tripping or alarms of ground fault protection on either source.

d. When any defects are detected, correct the defects and repeat the tests as requested by the COR at no additional cost to the Government.

3.3 FIELD SETTINGS VERIFICATION

A. The automatic transfer switch settings shall be verified in the field by an authorized representative of the manufacturer.

3.4 FOLLOW-UP VERIFICATION

A. Upon completion of acceptance checks and tests, the Contractor shall show by demonstration in service that the automatic transfer switches

are in good operating condition and properly performing the intended function.

3.5 INSTRUCTION

A. Furnish the services of a factory-trained technician for one 4-hour training period for instructing personnel in the maintenance and operation of the automatic transfer switches, on the dates requested by the COR.

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SECTION 26 41 00
FACILITY LIGHTNING PROTECTION

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing and installation of a complete UL master labeled lightning protection system.

1.2 RELATED WORK

A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.

B. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path to ground for possible ground faults.

C. Section 26 43 13, SURGE PROTECTIVE DEVICES: Surge protective device installed at the electrical service entrance.

1.3 QUALITY ASSURANCE

A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:

1. Shop Drawings:
   a. Submit sufficient information to demonstrate compliance with drawings and specifications.
   b. Show locations of air terminals, connections to required metal surfaces, down conductors, and grounding means.
   c. Show the mounting hardware and materials used to attach air terminals and conductors to the structure.
2. Certifications: Two weeks prior to final inspection, submit the following.
   a. Certification by the manufacturer that the lightning protection system conforms to the requirements of the drawings and specifications.
   b. Certification by the Contractor that the lightning protection system has been properly installed and inspected.

c. Certification that the lightning protection system has been inspected by a UL representative and has been approved by UL without variation.

1.5 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

B. National Fire Protection Association (NFPA):

70-23.....National Electrical Code (NEC)

780-23.....Standard for the Installation of Lightning Protection Systems

C. Underwriters Laboratories, Inc. (UL):

96-16.....Lightning Protection Components

96A-16.....Installation Requirements for Lightning Protection Systems

467-22.....Standard for Grounding and Bonding Equipment

PART 2 – PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Lightning protection components shall conform to NFPA 780 and UL 96, for use on Class II structures. Copper materials are required.

1. Class II conductors: Copper.
2. Class II air terminals: Solid copper, 18 inches long, not less than 1/2 inch diameter, with sharp nickel-plated points.
4. Ground rods: Copper-Clad steel, 0.75 in (19 mm) diameter by 3 m (10 feet) long.
5. Ground plates: Solid copper, not less than 20 gauge.
6. Bonding plates: Bronze, 50 square cm (8 square inches).
7. Through roof connectors: Solid copper riser bar, length and type as required to accommodate roof structure and flashing requirements.
8. Down conductor guards: Stiff copper or brass.
9. Anchors and fasteners: Bronze bolt and clamp type shall be used for all applications except for membrane roof. Adhesive type are allowed only for attachment to membrane roof materials, using adhesive that is compatible with the membrane material.
10. Connectors: Bronze clamp-type connectors shall be used for roof conductor splices, and the connection of the roof conductor to air

terminals and bonding plates. Crimp-type connectors are not allowed.

11. Exothermic welds: Exothermic welds shall be used for splicing the roof conductor to the down conductors, splices of the down conductors, and for connection of the down conductors to ground rods, ground plates, and the ground ring.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation shall be in accordance with the NEC, as shown on the drawings, and manufacturer's instructions.

B. Coordinate installation with the roofing manufacturer and roofing installer.

C. Install the conductors as inconspicuously as practical.

D. Install the down conductors within the concealed cavity of exterior walls where practical. Run the down conductors to the exterior at elevations below the finished grade.

E. Where down conductors are subject to damage or are accessible near grade, protect with down conductor guards to 2.4 m (8 feet) above grade. Bond down conductors guards to down conductor at both ends.

F. Make connections of dissimilar metal with bimetallic type fittings to prevent electrolytic action.

G. Install ground rods and ground plates not less than 600 mm (2 feet) deep and a distance not less than 900 mm (3 feet) nor more than 2.5 m (8 feet) from the nearest point of the structure. Exothermically weld the down conductors to ground rods and ground plates in the presence of the COR.

H. Bond down conductors to metal main water piping where applicable.

I. Bond down conductors to building structural steel.

J. Connect roof conductors to all metallic projections and equipment above the roof as indicated on the drawings.

K. Connect exterior metal surfaces, located within 900 mm (3 feet) of the conductors, to the conductors to prevent flashovers.

L. Maintain horizontal or downward coursing of main conductor and insure that all bends have at least an 200 mm (8 inches) radius and do not exceed 90 degrees.

M. Conductors shall be rigidly fastened every 900 mm (3 feet) along the roof and down to the building to ground.

N. Air terminals shall be secured against overturning either by attachment to the object to be protected or by means of a substantial tripod or other braces permanently and rigidly attached to the building or structure.

O. Install air terminal bases, cable holders and other roof-system supporting means without piercing membrane or metal roofs.

P. Use through-roof connectors for penetration of the roof system. Flashing shall be provided by roofing contractor in accordance with Section 07 60 00, FLASHING AND SHEET METAL.

Q. Down conductors coursed on or in reinforced concrete columns or on structural steel columns shall be connected to the reinforcing steel or the structural steel member at its upper and lower extremities. In the case of long vertical members an additional connection shall be made at intervals not exceeding 30 M (100 feet).

R. A counterpoise or ground ring, where shown, shall be of No. 1/0 copper cable having suitable resistance to corrosion and shall be laid around the perimeter of the structure in a trench not less than 600 mm (2 feet) deep at a distance not less than 900 mm (3 feet) nor more than 2.5 M (8 feet) from the nearest point of the structure.

S. On construction utilizing post tensioning systems to secure precast concrete sections, the post tension rods shall not be used as a path for lightning to ground.

T. Where shown, use the structural steel framework or reinforcing steel as the down conductor.

1. Weld or bond the non-electrically-continuous sections together and make them electrically continuous.
2. Verify the electrical continuity by measuring the ground resistances to earth at the ground level, at the top of the building or stack, and at intermediate points with a sensitive ohmmeter. Compare the resistance readings.
3. Connect the air terminals together with an exterior conductor connected to the structural steel framework at not more than 18 M (60 feet) intervals.
4. Install ground connections to earth at not more than 18 M (60 feet) intervals around the perimeter of the building.
5. Weld or braze bonding plates to cleaned sections of the steel and connect the conductors to the plates.

6. Do not pierce the structural steel in any manner. Connections to the structural steel shall conform to UL 96A.

3.2 ACCEPTANCE CHECKS AND TESTS

A. Test the ground resistance to earth by standard methods, and conform to the ground resistance requirements specified in Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

B. A UL representative shall inspect the lightning protection system. Obtain and install a UL numbered master label for each of the lightning protection systems at the location directed by the UL representative and the COR.

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SECTION 26 43 13
SURGE PROTECTIVE DEVICES

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the furnishing, installation, and connection of Type 2 Surge Protective Devices, as defined in NFPA 70, and indicated as SPD in this section.

1.2 RELATED WORK

A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.

B. Section 26 24 13, DISTRIBUTION SWITCHBOARDS: For factory-installed or external SPD.

C. Section 26 24 16, PANELBOARDS: For factory-installed or external SPD.

1.3 QUALITY ASSURANCE

A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:

1. Shop Drawings:
   a. Submit sufficient information to demonstrate compliance with drawings and specifications.
   b. Include electrical ratings and device nameplate data.
2. Manuals:
   a. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals including technical data sheets, wiring diagrams, and information for ordering replacement parts.
   b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
3. Certifications: Two weeks prior to final inspection, submit the following.
   a. Certification by the manufacturer that the SPD conforms to the requirements of the drawings and specifications.

b. Certification by the Contractor that the SPD has been properly installed.

1.5 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplement and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by the basic designation only.

B. Institute of Engineering and Electronic Engineers (IEEE):

IEEE C62.41.2-02.....Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits

IEEE C62.45-08.....Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits

C. National Fire Protection Association (NFPA):

70-23.....National Electrical Code (NEC)

D. Underwriters Laboratories, Inc. (UL):

UL 1283-17.....Electromagnetic Interference Filters

UL 1449-21.....Surge Protective Devices

PART 2 - PRODUCTS

2.1 SWITCHGEAR/SWITCHBOARD SPD

A. General Requirements:

1. Comply with IEEE and UL.
2. Modular design with field-replaceable modules, or non-modular design.
3. Fuses, rated at 200 kA interrupting capacity.
4. Bolted compression lugs for internal wiring.
5. Integral disconnect switch.
6. Redundant suppression circuits.
7. LED indicator lights for power and protection status.
8. Audible alarm, with silencing switch, to indicate when protection has failed.
9. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device.
10. Four-digit transient-event counter.

B. Surge Current per Phase: Minimum 240kA per phase.

2.2 PANELBOARD SPD

A. General Requirements:

1. Comply with UL 1449 and IEEE C62.41.2.
2. Modular design with field-replaceable modules, or non-modular design.
3. Fuses, rated at 200 kA interrupting capacity.
4. Bolted compression lugs for internal wiring.
5. Integral disconnect switch.
6. Redundant suppression circuits.
7. LED indicator lights for power and protection status.
8. Audible alarm, with silencing switch, to indicate when protection has failed.
9. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device.
10. Four-digit transient-event counter.

B. Surge Current per Phase: Minimum 120kA per phase.

2.3 ENCLOSURES

A. Enclosures: NEMA 1.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation shall be in accordance with the NEC, as shown on the drawings, and manufacturer’s instructions.

B. Factory-installed SPD: Switchgear, switchboard, or panelboard manufacturer shall install SPD at the factory.

C. Field-installed SPD: Contractor shall install SPD with conductors or buses between SPD and points of attachment as short and straight as possible. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.

1. Provide a circuit breaker as a dedicated disconnecting means for TVSS as shown on drawings.

D. Do not perform insulation resistance tests on switchgear, switchboards, panelboards, or feeders with the SPD connected. Disconnect SPD before conducting insulation resistance tests, and reconnect SPD immediately after insulation resistance tests are complete.

3.2 ACCEPTANCE CHECKS AND TESTS

A. Perform in accordance with the manufacturer's recommendations. In addition, include the following:

1. Visual Inspection and Tests:

a. Compare equipment nameplate data with specifications and approved shop drawings.
b. Inspect physical, electrical, and mechanical condition.
c. Verify that disconnecting means and feeder size and maximum length to SPD corresponds to approved shop drawings.
d. Verifying tightness of accessible bolted electrical connections by calibrated torque-wrench method.
e. Vacuum-clean enclosure interior. Clean enclosure exterior.
f. Verify the correct operation of all sensing devices, alarms, and indicating devices.

3.3 FOLLOW-UP VERIFICATION

A. After completion of acceptance checks and tests, the Contractor shall show by demonstration in service that SPD are in good operating condition and properly performing the intended function.

3.4 INSTRUCTION

A. Provide the services of a factory-trained technician for one 2-hour training period for instructing personnel in the maintenance and operation of the SPD, on the date requested by the COR.

`---END---

SECTION 26 51 00
INTERIOR LIGHTING

PART 1 - GENERAL

1.1 DESCRIPTION:

A. This section specifies the furnishing, installation, and connection of the interior lighting systems. The terms "lighting fixture," "fixture," and "luminaire" are used interchangeably.

1.2 RELATED WORK

A. Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT: Disposal of lamps.
B. Section 02 41 00, SELECTIVE DEMOLITION: Removal and disposal of lamps and ballasts.
C. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.
D. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Low-voltage conductors.
E. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path to ground for possible ground fault currents.
F. Section 26 27 26, WIRING DEVICES: Wiring devices used for control of the lighting systems.

1.3 QUALITY ASSURANCE

A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:
   1. Shop Drawings:
      a. Submit the following information for each type of lighting fixture designated on the LIGHTING FIXTURE SCHEDULE, arranged in order of lighting fixture designation.
      b. Material and construction details, include information on housing and optics system.
      c. Physical dimensions and description.

d. Wiring schematic and connection diagram.

e. Installation details.

f. Energy efficiency data.

g. Photometric data based on laboratory tests complying with IES Lighting Measurements testing and calculation guides.

h. Lamp data including lumen output (initial and mean), color rendition index (CRI), rated life (hours), and color temperature (degrees Kelvin).

i. Ballast data including ballast type, starting method, ambient temperature, ballast factor, sound rating, system watts, and total harmonic distortion (THD).

j. For LED lighting fixtures, submit US DOE LED Lighting Facts label, and IES L70 rated life.

2. Manuals:

a. Submit, simultaneously with the shop drawings, complete maintenance and operating manuals, including technical data sheets, wiring diagrams, and information for ordering replacement parts.

b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.

3. Certifications: Two weeks prior to final inspection, submit the following.

a. Certification by the Contractor that the interior lighting systems have been properly installed and tested.

1.5 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

B. American Society for Testing and Materials (ASTM):
C635/C635M-22.....Manufacture, Performance, and Testing of Metal Suspension Systems for Acoustical Tile and Lay-in Panel Ceilings

C. Environmental Protection Agency (EPA):
40 CFR 261-21.....Identification and Listing of Hazardous Waste

D. Federal Communications Commission (FCC):
CFR Title 47, Part 15...Radio Frequency Devices

CFR Title 47, Part 18...Industrial, Scientific, and Medical Equipment

E. Illuminating Engineering Society of North America (IESNA):

LM-79-19.....Electrical and Photometric Measurements of Solid-State Lighting Products

LM-80-21.....Measuring Lumen Maintenance of LED Light Sources

LM-82-19.....Characterization of LED Light Engines and LED Lamps for Electrical and Photometric Properties as a Function of Temperature

F. Institute of Electrical and Electronic Engineers (IEEE):

C62.41-91(R1995).....Surge Voltages in Low Voltage AC Power Circuits

G. International Code Council (ICC):

IBC-21.....International Building Code

H. National Electrical Manufacturer's Association (NEMA):

C78.376-14 (R2021).....Chromaticity of Fluorescent Lamps

C82.1-04(S2021).....Lamp Ballasts – Line Frequency Fluorescent Lamp Ballasts

C82.2-02(S2021).....Method of Measurement of Fluorescent Lamp Ballasts

C82.4-17.....Lamp Ballasts - Ballasts for High-Intensity Discharge and Low-Pressure Sodium (LPS) Lamps (Multiple-Supply Type)

C82.11-17.....Lamp Ballasts - High Frequency Fluorescent Lamp Ballasts

LL 9-11.....Dimming of T8 Fluorescent Lighting Systems

SSL 1-16.....Electronic Drivers for LED Devices, Arrays, or Systems

I. National Fire Protection Association (NFPA):

70-23.....National Electrical Code (NEC)

101-21.....Life Safety Code

J. Underwriters Laboratories, Inc. (UL):

496-17.....Lampholders

542-05.....Fluorescent Lamp Starters

844-12.....Luminaires for Use in Hazardous (Classified) Locations

924-16.....Emergency Lighting and Power Equipment

935-01.....Fluorescent-Lamp Ballasts

1029-94.....High-Intensity-Discharge Lamp Ballasts

1029A-06.....Outline of Investigation for Ignitors and Related Auxiliaries for HID Lamp Ballasts
1574-04.....Standard for Safety Track Lighting Systems
1598-21.....Standard for Safety Luminaires
2108-15.....Standard for Safety Low-Voltage Lighting Systems
8750-15.....Standard for Safety Light Emitting Diode (LED) Light Sources for Use in Lighting Products

PART 2 - PRODUCTS

2.1 LIGHTING FIXTURES

A. Shall be in accordance with NFPA, UL, as shown on drawings, and as specified.

B. Sheet Metal:

1. Shall be formed to prevent warping and sagging. Housing, trim and lens frame shall be true, straight (unless intentionally curved), and parallel to each other as designed.
2. Wireways and fittings shall be free of burrs and sharp edges, and shall accommodate internal and branch circuit wiring without damage to the wiring.
3. When installed, any exposed fixture housing surface, trim frame, door frame, and lens frame shall be free of light leaks.
4. Hinged door frames shall operate smoothly without binding. Latches shall function easily by finger action without the use of tools.

C.

E. Recessed fixtures mounted in an insulated ceiling shall be listed for use in insulated ceilings.

F. Mechanical Safety: Lighting fixture closures (lens doors, trim frame, hinged housings, etc.) shall be retained in a secure manner by captive screws, chains, aircraft cable, captive hinges, or fasteners such that they cannot be accidentally dislodged during normal operation or routine maintenance.

G. Metal Finishes:

1. The manufacturer shall apply standard finish (unless otherwise specified) over a corrosion-resistant primer, after cleaning to free the metal surfaces of rust, grease, dirt and other deposits. Edges of pre-finished sheet metal exposed during forming, stamping or shearing processes shall be finished in a similar corrosion

resistant manner to match the adjacent surface(s). Fixture finish shall be free of stains or evidence of rusting, blistering, or flaking, and shall be applied after fabrication.

2. Interior light reflecting finishes shall be white with not less than 85 percent reflectances, except where otherwise shown on the drawing.
3. Exterior finishes shall be as shown on the drawings.

H. Lighting fixtures shall have a specific means for grounding metallic wireways and housings to an equipment grounding conductor.

2.1 LED EXIT LIGHT FIXTURES

A. Exit light fixtures shall meet applicable requirements of NFPA and UL.

B. Housing and door shall be die-cast aluminum.

C. For general purpose exit light fixtures, door frame shall be hinged, with latch. For vandal-resistant exit light fixtures, door frame shall be secured with tamper-resistant screws.

D. Finish shall be satin or fine-grain brushed aluminum.

E. There shall be no radioactive material used in the fixtures.

F. Fixtures:

1. Inscription panels shall be cast or stamped aluminum a minimum of 2.25 mm (0.090 inch) thick, stenciled with 150 mm (6 inch) high letters, baked with red color stable plastic or fiberglass. Lamps shall be luminous Light Emitting Diodes (LED) mounted in center of letters on red color stable plastic or fiberglass.
2. Double-Faced Fixtures: Provide double-faced fixtures where required or as shown on drawings.
3. Directional Arrows: Provide directional arrows as part of the inscription panel where required or as shown on drawings. Directional arrows shall be the "chevron-type" of similar size and width as the letters and meet the requirements of NFPA 101.

G. Voltage: Multi-voltage (120 – 277V).

2.10 LED LIGHT FIXTURES

A. General:

1. LED light fixtures shall be in accordance with IES, NFPA, UL, as shown on the drawings, and as specified.
2. LED light fixtures shall be Reduction of Hazardous Substances (RoHS)-compliant.

3. LED drivers shall include the following features unless otherwise indicated:
   a. Minimum efficiency: 85% at full load.
   b. Minimum Operating Ambient Temperature: -20˚ C. (-4˚ F.)
   c. Input Voltage: 120 - 277V (±10%) at 60 Hz.
   d. Integral short circuit, open circuit, and overload protection.
   e. Power Factor: ≥ 0.95.
   f. Total Harmonic Distortion: ≤ 20%.
   g. Comply with FCC 47 CFR Part 15.
4. LED modules shall include the following features unless otherwise indicated:
   a. Comply with IES LM-79 and LM-80 requirements.
   b. Minimum CRI: 80 or higher. Minimum Color Fidelity Index (IES Rf): 80 or higher.
   c. Color temperature between 3500° - 5000°K and as specified in the drawings' LIGHTING FIXTURE SCHEDULE.
   d. Minimum Rated Life: 50,000 hours per IES L70.
   e. Light output lumens as indicated in the LIGHTING FIXTURE SCHEDULE.

B. LED Downlights:
1. Housing, LED driver, and LED module shall be products of the same manufacturer.

C. LED Troffers:
1. LED drivers, modules, and reflector shall be accessible, serviceable, and replaceable from below the ceiling.
2. Housing, LED driver, and LED module shall be products of the same manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation shall be in accordance with the NEC, manufacturer's instructions, and as shown on the drawings or specified.
B. Align, mount, and level the lighting fixtures uniformly.
C. Wall-mounted fixtures shall be attached to the studs in the walls, or to a 20 gauge metal backing plate that is attached to the studs in the

walls. Lighting fixtures shall not be attached directly to gypsum board.

D. Lighting Fixture Supports:
   1. Shall provide support for all of the fixtures. Supports may be anchored to channels of the ceiling construction, to the structural slab or to structural members within a partition, or above a suspended ceiling.
   2. Shall maintain the fixture positions after cleaning.
   3. Shall support the lighting fixtures without causing the ceiling or partition to deflect.

   4. Surface mounted lighting fixtures:
      a. Fixtures shall be bolted against the ceiling independent of the outlet box at four points spaced near the corners of each unit. The bolts (or stud-clips) shall be minimum 6 mm (1/4 inch) bolt, secured to main ceiling runners and/or secured to cross runners. Non-turning studs may be attached to the main ceiling runners and cross runners with special non-friction clip devices designed for the purpose, provided they bolt through the runner, or are also secured to the building structure by 12 gauge safety hangers. Studs or bolts securing fixtures weighing in excess of 25 kg (56 pounds) shall be supported directly from the building structure.
      b. Where ceiling cross runners are installed for support of lighting fixtures, they must have a carrying capacity equal to that of the main ceiling runners and be rigidly secured to the main runners.
      c. Fixtures less than 6.8 kg (15 pounds) in weight and occupying less than 3715 sq cm (two square feet) of ceiling area may, when designed for the purpose, be supported directly from the outlet box when all the following conditions are met.
         1) Screws attaching the fixture to the outlet box pass through round holes (not key-hole slots) in the fixture body.
         2) The outlet box is attached to a main ceiling runner (or cross runner) with approved hardware.
         3) The outlet box is supported vertically from the building structure.

d. Fixtures mounted in open construction shall be secured directly to the building structure with approved bolting and clamping devices.

5. Single or double pendant-mounted lighting fixtures:

a. Each stem shall be supported by an approved outlet box mounted swivel joint and canopy which holds the stem captive and provides spring load (or approved equivalent) dampening of fixture oscillations. Outlet box shall be supported vertically from the building structure.

9. Outlet boxes for support of lighting fixtures (where permitted) shall be secured directly to the building structure with approved devices or supported vertically in a hung ceiling from the building structure with a nine gauge wire hanger, and be secured by an approved device to a main ceiling runner or cross runner to prevent any horizontal movement relative to the ceiling.

E. Furnish and install the new lamps as specified for all lighting fixtures installed under this project, and for all existing lighting fixtures reused under this project.

F. The electrical and ceiling trades shall coordinate to ascertain that approved lighting fixtures are furnished in the proper sizes and installed with the proper devices (hangers, clips, trim frames, flanges, etc.), to match the ceiling system being installed.

G. Bond lighting fixtures to the grounding system as specified in Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

H. At completion of project, replace all defective components of the lighting fixtures at no cost to the Government.

I. Dispose of lamps per requirements of Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT.

3.2 ACCEPTANCE CHECKS AND TESTS

A. Perform the following:

1. Visual Inspection:

a. Verify proper operation by operating the lighting controls.

b. Visually inspect for damage to fixtures, lenses, reflectors, diffusers, and louvers. Clean fixtures, lenses, reflectors, diffusers, and louvers that have accumulated dust, dirt, or fingerprints during construction.

2. Electrical tests:

a. Exercise dimming components of the lighting fixtures over full range of dimming capability by operating the control devices(s) in the presence of the COR. Observe for visually detectable flicker over full dimming range, and replace defective components at no cost to the Government.

b. Burn-in all lamps that require specific aging period to operate properly, prior to occupancy by Government. Burn-in period to be 40 hours minimum, unless specifically recommended otherwise by the lamp manufacturer. Burn-in dimmed fluorescent and compact fluorescent lamps for at least 100 hours at full voltage, unless specifically recommended otherwise by the lamp manufacturer. Replace any lamps and ballasts which fail during burn-in.

3.3 FOLLOW-UP VERIFICATION

A. Upon completion of acceptance checks and tests, the Contractor shall show by demonstration in service that the lighting systems are in good operating condition and properly performing the intended function.

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SECTION 26 56 00
EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 DESCRIPTION

This section specifies the furnishing, installation, and connection of exterior fixtures, poles, and supports. The terms "lighting fixtures", "fixture" and "luminaire" are used interchangeably.

1.2 RELATED WORK

A. Section 03 30 00, CAST-IN-PLACE CONCRETE.

B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements and items that are common to more than one section of Division 26.

C. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW): Low voltage power and lighting wiring.

D. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.

E. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits, fittings, and boxes for raceway systems.

F. Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION: Underground handholes and conduits.

G. Section 26 09 23, LIGHTING CONTROLS: Controls for exterior lighting.

1.3 QUALITY ASSURANCE

A. Quality Assurance shall be in accordance with Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES) in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

A. Submit in accordance with Paragraph, SUBMITTALS in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS, and the following requirements:

1. Shop Drawings:

a. Submit the following information for each type of lighting fixture designated on the LIGHTING FIXTURE SCHEDULE, arranged in order of lighting fixture designation.

b. Material and construction details, include information on housing and optics system.

c. Physical dimensions and description.

d. Wiring schematic and connection diagram.

e. Installation details.

f. Energy efficiency data.

g. Photometric data based on laboratory tests complying with IES Lighting Measurements testing and calculation guides.

h. Lamp data including lumen output (initial and mean), color rendition index (CRI), rated life (hours), and color temperature (degrees Kelvin).

i. Ballast data including ballast type, starting method, ambient temperature, ballast factor, sound rating, system watts, and total harmonic distortion (THD).

j. For LED lighting fixtures, submit US DOE LED Lighting Facts label, and IES L70 rated life.

k. Submit site plan showing all exterior lighting fixtures with fixture tags consistent with Lighting Fixture Schedule as shown on drawings. Site plan shall show computer generated point-by-point illumination calculations. Include lamp lumen and light loss factors used in calculations.

2. Manuals:

a. Submit, simultaneously with the shop drawings, complete maintenance and operating manuals, including technical data sheets, wiring diagrams, and information for ordering replacement parts.

b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.

3. Certifications: Two weeks prior to final inspection, submit the following.

a. Certification by the Contractor that the exterior lighting systems have been properly installed and tested.

1.5 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

B. American Association of State Highway and Transportation Officials (AASHTO):

LRFDLTS-17.....Structural Supports for Highway Signs, Luminaires and Traffic Signals

C. American Concrete Institute (ACI):

318-14 .....Building Code Requirements for Structural Concrete

D. American National Standards Institute (ANSI):

H35.1/H35 1M-17.....American National Standard Alloy and Temper Designation Systems for Aluminum

E. American Society for Testing and Materials (ASTM):

A123/A123M-17 .....Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

A153/A153M-16.....Zinc Coating (Hot-Dip) on Iron and Steel Hardware

B108/B108M-15 .....Aluminum-Alloy Permanent Mold Castings

C1089-13 .....Spun Cast Prestressed Concrete Poles

F. Federal Aviation Administration (FAA):

AC 70/7460-IL-15.....Obstruction Lighting and Marking

AC 150/5345-43H-16.....Obstruction Lighting Equipment

G. Illuminating Engineering Society of North America (IESNA):

HB-9-00.....Lighting Handbook

RP-8-14.....Roadway Lighting

LM-52-03.....Photometric Measurements of Roadway Sign Installations

LM-72-97(R2010).....Directional Positioning of Photometric Data

LM-79-08.....Approved Method for the Electrical and Photometric Measurements of Solid-Sate Lighting Products

LM-80-15.....Approved Method for Measuring Luminous Flux and Color Maintenance of LED Packages, Arrays and Modules

TM-15-11.....Luminaire Classification System for Outdoor Luminaires

H. National Electrical Manufacturers Association (NEMA):

C78.41-16.....Electric Lamps – Guidelines for Low-Pressure Sodium Lamps

C78.42-09(R2016) .....Electric Lamps – Guidelines for High-Pressure Sodium Lamps

C78.43-13 .....Electric Lamps – Single-Ended Metal-Halide Lamps

C78.1381-98.....Electric Lamps – 70-Watt M85 Double-Ended Metal-Halide Lamps

C81.61-17 .....Electrical Lamp Bases – Specifications for Bases (Caps) for Electric Lamps

C82.4-17 .....Ballasts for High-Intensity-Discharge and Low-Pressure Sodium Lamps (Multiple-Supply Type)

C136.3-14 .....For Roadway and Area Lighting Equipment – Luminaire Attachments

C136.17-05(R2010)(S2017) Roadway and Area Lighting Equipment – Enclosed Side-Mounted Luminaires for Horizontal-Burning High-Intensity-Discharge Lamps – Mechanical Interchangeability of Refractors

ICS 2-00(R2005) .....Controllers, Contactors and Overload Relays Rated 600 Volts

ICS 6-93(R2016) .....Enclosures

I. National Fire Protection Association (NFPA):

70-17 .....National Electrical Code (NEC)

101-18.....Life Safety Code

J. Underwriters Laboratories, Inc. (UL):

496-17 .....Lampholders

773-16.....Plug-In, Locking Type Photocontrols for Use with Area Lighting

773A-16 .....Nonindustrial Photoelectric Switches for Lighting Control

1029-94.....High-Intensity-Discharge Lamp Ballasts

1598-08 .....Luminaires

8750-15.....Light Emitting Diode (LED) Equipment for Use in Lighting Products

1.6 DELIVERY, STORAGE, AND HANDLING

Provide manufacturer’s standard provisions for protecting pole finishes during transport, storage, and installation. Do not store poles on ground. Store poles so they are at least 305 mm (12 inches) above

ground level and growing vegetation. Do not remove factory-applied pole wrappings until just before installing pole.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

Luminaires, materials and equipment shall be in accordance with NEC, UL, ANSI, and as shown on the drawings and specified.

2.2 POLES

A. General:

1. Poles shall be as shown on the drawings, and as specified. Finish shall be as specified on the drawings.

2. The pole and arm assembly shall be designed for wind loading of 100 mph minimum, as required by wind loading conditions at project site, with an additional 30% gust factor and supporting luminaire(s) and accessories such as shields, banner arms, and banners that have the effective projected areas indicated. The effective projected area of the pole shall be applied at the height of the pole base, as shown on the drawings.
3. Poles shall be anchor-bolt type designed for use with underground supply conductors. Poles shall have handhole having a minimum clear opening of 65 x 125 mm (2.5 x 5 inches). Handhole covers shall be secured by stainless steel captive screws.
4. Provide a steel-grounding stud opposite handhole openings, designed to prevent electrolysis when used with copper wire.
5. Provide a base cover that matches the pole in material and color to conceal the mounting hardware pole-base welds and anchor bolts.
6. Hardware and Accessories: All necessary hardware and specified accessories shall be the product of the pole manufacturer.
7. Provide manufacturer's standard finish, as scheduled on the drawings. Where indicated on drawings, provide finishes as indicated in Section 09 06 00, SCHEDULE FOR FINISHES.

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B. Types:

1. Aluminum: Provide square aluminum poles manufactured of corrosion-resistant AA AAH35.1 aluminum alloys conforming to AASHTO LTS-4. Poles shall be seamless extruded or spun seamless type.

2.3 FOUNDATIONS FOR POLES

A. Foundations shall be cast-in-place concrete, having 3000 psi minimum 28-day compressive strength.

B. Foundations shall support the effective projected area of the specified pole, arm(s), luminaire(s), and accessories, such as shields, banner arms, and banners, under wind conditions previously specified in this section.

C. Place concrete in spirally-wrapped treated paper forms for round foundations, and construct forms for square foundations.

D. Rub-finish and round all above-grade concrete edges to approximately 6 mm (0.25-inch) radius.

E. Anchor bolt assemblies and reinforcing of concrete foundations shall be as shown on the drawings. Anchor bolts shall be in a welded cage or properly positioned by the tiewire to stirrups.

F. Prior to concrete pour, install electrode per Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

2.4 LUMINAIRES

A. Luminaires shall be weatherproof, heavy duty, outdoor types designed for efficient light utilization, adequate dissipation of lamp and ballast heat, and safe cleaning and relamping.

B. Illumination distribution patterns, BUG ratings and cutoff types as defined by the IESNA shall be as shown on the drawings.

C. Incorporate ballasts in the luminaire housing, except where otherwise shown on the drawings.

D. Lenses shall be frame-mounted, heat-resistant, borosilicate glass, with prismatic refractors, unless otherwise shown on the drawings. Attach the frame to the luminaire housing by hinges or chain. Use heat and aging-resistant, resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

E.

F. Pre-wire internal components to terminal strips at the factory.

G. Bracket-mounted luminaires shall have leveling provisions and clamp-type adjustable slip-fitters with locking screws.

H. Materials shall be rustproof. Latches and fittings shall be non-ferrous metal.

I. Provide manufacturer's standard finish, as scheduled on the drawings. Where indicated on drawings, match finish process and color of pole or support materials. Where indicated on drawings, provide finishes as indicated in Section 09 06 00, SCHEDULE FOR FINISHES.

J. Luminaires shall carry factory labels, showing complete, specific lamp and ballast information.

2.5 LAMPS

F. LED sources shall meet the following requirements:

1. Operating temperature rating shall be between -40 degrees C (-40 degrees F) and 50 degrees C (120 degrees F).
2. Correlated Color Temperature (CCT): As indicated in the Luminaire Schedule.
3. Color Rendering Index (CRI): ≥ 85.
4. The manufacturer shall have performed reliability tests on the LEDs luminaires complying with Illuminating Engineering Society (IES) LM79 for photometric performance and LM80 for lumen maintenance and L70 life.

2.6 LED DRIVERS

A. LED drivers shall meet the following requirements:

1. Drivers shall have a minimum efficiency of 85%.
2. Starting Temperature: -40 degrees C (-40 degrees F).
3. Input Voltage: 120 to 480 (±10%) volt.
4. Power Supplies: Class I or II output.
5. Surge Protection: The system must survive 250 repetitive strikes of “C Low” (C Low: 6kV/1.2 x 50 µs, 10kA/8 x 20 µs) waveforms at 1-minute intervals with less than 10% degradation in clamping voltage. “C Low” waveforms are as defined in IEEE/ASNI C62.41.2-2002, Scenario 1 Location Category C.
6. Power Factor (PF): ≥ 0.90.
7. Total Harmonic Distortion (THD): ≤ 20%.
8. Comply with FCC Title 47 CFR Part 18 Non-consumer RFI/EMI Standards.
9. Drivers shall be reduction of hazardous substances (ROHS)-compliant.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install lighting in accordance with the NEC, as shown on the drawings, and in accordance with manufacturer's recommendations.

B. Pole Foundations:

1. Excavate only as necessary to provide sufficient working clearance for installation of forms and proper use of tamper to the full depth of the excavation. Prevent surface water from flowing into the excavation. Thoroughly compact backfill with compacting arranged to prevent pressure between conductor, jacket, or sheath, and the end of conduit.
2. Set anchor bolts according to anchor-bolt templates furnished by the pole manufacturer.
3. Install poles as necessary to provide a permanent vertical position with the bracket arm in proper position for luminaire location.
4. After the poles have been installed, shimmed, and plumbed, grout the spaces between the pole bases and the concrete base with non-shrink concrete grout material. Provide a plastic or copper tube, of not less than 9 mm (0.375-inch) inside diameter through the grout, tight to the top of the concrete base to prevent moisture weeping from the interior of the pole.

C. Install lamps in each luminaire.

D. Adjust luminaires that require field adjustment or aiming.

3.2 GROUNDING

Ground noncurrent-carrying parts of equipment, including metal poles, luminaires, mounting arms, brackets, and metallic enclosures, as specified in Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS. Where copper grounding conductor is connected to a metal other than copper, provide specially-treated or lined connectors suitable and listed for this purpose.

3.3 ACCEPTANCE CHECKS AND TESTS

Verify operation after installing luminaires and energizing circuits.

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