21 OCTOBER 2025

# EHRM INFRASTRUCTURE UPGRADES

PROJECT #: 528A7-22-700

SYRACUSE VA MEDICAL CENTER
SYRACUSE, NY

# SPECIFICATIONS

## Divisions 21-23

## 100% SUBMITTAL
CONSTRUCTION DOCUMENTS 2

SDB SPEESDESIGNBUILD

**DEPARTMENT OF VETERANS AFFAIRS**
**VHA MASTER SPECIFICATIONS**

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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) 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 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 systems listed in Section 01 91 00 General Commissioning Requirements

**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.

----- END -----

**SECTION 21 13 13**
**WET-PIPE SPRINKLER SYSTEMS**

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

A. Design, installation and testing shall be in accordance with
    a. NFPA 13.
B. Modification of the existing sprinkler system as indicated on the drawings and as further required by these specifications.

**1.2 RELATED WORK**

A. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
B. Section 07 84 00, FIRESTOPPING.
D. Section 09 91 00, PAINTING.
E. Section 22 05 23, GENERAL-DUTY VALVES FOR PLUMBING PIPING.
F. 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 and Data Center's..
        b. Ordinary Hazard Group 1 Occupancies: Laboratories, Mechanical Equipment Rooms, Transformer Rooms, Electrical Switchgear Rooms, Electric Closets, and Repair Shops.
    3. Hydraulic Calculations: Calculated demand including hose stream requirements shall fall no less than 10 percent below the available water supply curve.

5. Zoning:
    a. For each sprinkler zone provide a control valve, flow switch, and a test and drain assembly with pressure gauge. For buildings greater than two stories, provide a check valve at each control valve.
    b. Sprinkler zones shall conform to the smoke barrier zones shown on the drawings.
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.

**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 contractors fire sprinkler and 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. Valve Charts: Provide a valve chart that identifies the location of each control valve. Coordinate nomenclature and identification of control valves with COR. Where existing nomenclature does not exist, the chart shall include no less than the following: Tag ID No., Valve Size, Service (control valve, main drain, aux. drain, inspectors test valve, etc.), and Location.
6. 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 New York) 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**

***Note: From the date contract documents are provided, the Contractor shall use the most current published versions of all listed standards and references below.**

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):

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

25-14 .....Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems

101-15 .....Life Safety Code

170-15 .....Fire Safety Symbols

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. 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.
3. Plastic piping shall not be permitted.
4. 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. Alarm Check Valve: Alarm check valve shall be UL Listed and Factory Mutual Approved. The alarm check valve shall be listed for installation in the vertical or horizontal position. The alarm check valve shall be equipped with a removable cover assembly, gauge connections on the system side and supply side of the valve clapper, variable pressure trim, and an external bypass to eliminate false water flow alarms. The alarm check valve trim piping shall be galvanized. Maximum water working pressure to 250 PSI.

**2.3 SPRINKLERS**

A. except Provide FM approved quick response sprinklers in all areas, except that standard response sprinklers shall be provided in telecommunication rooms and data centers.

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.

C. Provide sprinkler guards in Telecommunication Rooms, Data Center's, and in accordance with NFPA 13 and when the elevation of the sprinkler head is less than 7 feet 6 inches above finished floor. The sprinkler guard shall be UL listed or FM approved for use with the corresponding sprinkler.

**2.4 SPRINKLER SYSTEM SIGNAGE**

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.

**2.5 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.

C. Alarm Pressure Switches: Activation by any flow of water equal to or in excess of the discharge from one sprinkler. The alarm pressure switch shall be UL Listed or Factory Mutual Approved for the application in which it is used. Activation of the alarm pressure switch shall cause an alarm on the fire alarm system control unit.

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

**2.6 GAUGES**

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

**2.7 PIPE HANGERS, SUPPORTS AND RESTRAINT OF SYSTEM PIPING**

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

**2.8 WALL, FLOOR AND CEILING PLATES**

Provide chrome plated steel escutcheon plates.

**2.9 VALVE TAGS**

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.

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

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

N. Painting of Pipe: In finished areas where walls and ceilings have been painted, paint primed surfaces with two coats of paint to match adjacent surfaces, except paint valves and operating accessories with two coats of gloss red enamel. Exercise care to avoid painting sprinklers. Painting of sprinkler systems above suspended ceilings and in crawl spaces is not required. Painting shall comply with Section 09 91 00, PAINTING. Any painted sprinkler shall be replaced with a new sprinkler.

O. 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.

P. 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.

Q. 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.

**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 22 00**
**CLEAN AGENT FIRE SUPPRESSION SYSTEMS**

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

A. 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.

**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 observable adverse effects level (NOAEL). Special means such as mechanical exhaust, shall not be permitted to be used to achieve this criterion.
    3. The clean agent shall have a global warming potential (GWP) of less than 4000 and the clean agent shall be readily available throughout the continental United States.
    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.

**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 Special Suppression Systems and 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 New York 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 PUIBLICATIONS**

***Note: From the date contract documents are provided, the Contractor shall use the most current published versions of all listed standards and references below.**

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 .....National Electric Code

72 .....National Fire Alarm Code

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

170 .....Fire Safety Symbols

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

C. Underwriters Laboratories, Inc. (UL):

2011..... Fire Protection Equipment Directory

D. Factory Mutual Engineering Corporation (FM):

2015..... 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**

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.

**2.2 CLEAN AGENT FIRE EXTINGUISHING SYSTEM**

A. General:

1. The clean agent fire extinguishing system shall be UL listed and shall be 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. Cylinder assemblies shall be of steel construction designed to meet the requirements of the U.S. Department of Transportation.
3. 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.
4. Cylinders shall be securely attached to the wall. Provide factory- or field-fabricated retaining brackets consisting of steel straps and channels; suitable for container support, maintenance, and tank refilling or replacement.
5. For halocarbon clean agents, storage cylinders shall be provided with a low agent pressure switch.

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 24 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. Nozzles shall be permanently marked with the manufacturer's part number. The nozzles shall be threaded directly to the discharge piping without the use of special adaptors.

**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.
2. 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.
3. 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.
4. 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. Reset2 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.
4. Each protected space shall have at least 2 detectors.
5. Provide red stickers with an “A” on the ceiling below the location of the above ceiling smoke detectors when above ceiling detectors are provided. Provide red stickers with a “U” on the ceiling above the location of the under floor smoke detectors. Each sticker shall also include the address of the detector. The address shall be the same as that address that shows on the fire alarm control unit when the detector is activated.
6. For smoke detectors located under the floor, the smoke detectors shall be mounted with a steel angle or channel support independent of the raised floor structure. The smoke detectors shall be mounted in a vertical orientation.

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).

**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. [Agent Surname] RELEASE IMMINENT". The sign shall be permanently affixed to the wall within 12 inches (304 mm) of the pre-discharge strobe.

F. Provide signage for the discharge strobes. The sign shall say "[Agent Surname] 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. The sign shall say "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 "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. Firestopping shall be provided for all penetrations of fire resistance rated construction. Firestopping shall comply with Section 07 84 00, FIRESTOPPING.

J. 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.

K. 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.

L. 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.

M. 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 AND TEST**

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: System function operation test system as specified in NFPA 2001 and NFPA 72, in the presence of the COR or his designated representative.

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. Two 4-hour sessions to electrical technicians for maintaining, programming, modifying, and repairing the system at the completion of installation and one 4-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 will apply to all sections of Division 22.

B. Definitions:

1. Exposed: Piping and equipment exposed to view in finished rooms.
2. Exterior: Piping and equipment exposed to weather be it temperature, humidity, precipitation, wind or solar radiation.

C. Abbreviations/Acronyms:

1. ABS: Acrylonitrile Butadiene Styrene
2. A/E: Architect/Engineer
3. AISI: American Iron and Steel Institute
4. ASJ: All Service Jacket
5. ASME: American Society of Mechanical Engineers
6. ASPE: American Society of Plumbing Engineers
7. AWG: American Wire Gauge
8. CD: Compact Disk
9. CDA: Copper Development Association
10. CGA: Compressed Gas Association
11. CFM: Cubic Feet per Minute
12. CI: Cast Iron
13. CLR: Color
14. CO: Contracting Officer
15. COR: Contracting Officer's Representative
16. CPVC: Chlorinated Polyvinyl Chloride
17. DHW: Domestic Hot Water
18. DHWR: Domestic Hot Water Return
19. DHWS: Domestic How Water Supply
20. DN: Diameter Nominal
21. DVD: Digital Video Disc
22. DWG: Drawing
23. DWS: Domestic Water Supply

24. DWV: Drainage, Waste and Vent
25. EL: Elevation
26. EPA: Environmental Protection Agency
27. EPACT: Energy Policy Act
28. EPDM: Ethylene Propylene Diene Monomer
29. EPT: Ethylene Propylene Terpolymer
30. ETO: Ethylene Oxide
31. F: Fahrenheit
32. FAR: Federal Acquisition Regulations
33. FD: Floor Drain
34. FED: Federal
35. FG: Fiberglass
36. FNPT: Female National Pipe Thread
37. FPM: Fluoroelastomer Polymer
38. FSK: Foil-Scrim-Kraft Facing
39. FSS: VA Construction & Facilities Management, Facility Standards Service
40. FU: Fixture Units
41. GAL: Gallon
42. GCO: Grade Cleanouts
43. GPD: Gallons per Day
44. GPH: Gallons per Hour
45. GPM: Gallons per Minute
46. ID: Inside Diameter
47. IPC: International Plumbing Code
48. IPS: Iron Pipe Size
49. IW: Indirect Waste
50. lb: Pound
51. MAX: Maximum
52. MFG: Manufacturer
53. MIN: Minimum
54. NPTF: National Pipe Thread Female
55. NPS: Nominal Pipe Size

56. NPT: Nominal Pipe Thread
57. NTS: Not to Scale
58. PP: Polypropylene
59. ppb: Parts per Billion
60. ppm: Parts per Million
61. PSI: Pounds per Square Inch
62. PSIA: Pounds per Square Inch Atmosphere
63. PSIG: Pounds per Square Inch Gauge
64. PTFE: Polytetrafluoroethylene
65. PVC: Polyvinyl Chloride
66. PVDF: Polyvinylidene Fluoride
67. SAN: Sanitary Sewer
68. SPEC: Specification
69. SQFT/SF: Square Feet
70. SS: Stainless Steel
71. STD: Standard
72. TIL: Technical Information Library http//www.cfm.va.gov/til/indes.asp
73. T/P: Temperature and Pressure
74. TYP: Typical
75. USDA: U.S. Department of Agriculture
76. V: Vent
77. VA: Veterans Administration
78. VA CFM: VA Construction & Facilities Management
79. VA CFM CSS: VA Construction & Facilities Management, Consulting Support Service
80. VAMC: Veterans Administration Medical Center
81. VHA OCAMES: This has been replaced by HEFP.
82. VTR: Vent through Roof
83. W: Waste
84. WAGD: Waste Anesthesia Gas Disposal
85. WC: Water Closet
86. WG: Water Gauge
87. WOG: Water, Oil, Gas

88. WPD: Water Pressure Drop

89. WSFU: Water Supply Fixture Units

**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 74 19, CONSTRUCTION WASTE MANAGEMENT.

D. Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.

E. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

F. Section 05 31 00, STEEL DECKING: Building Components for Attachment of Hangers.

G. Section 05 36 00, COMPOSITE METAL DECKING: Building Components for Attachment of Hangers.

H. Section 05 50 00, METAL FABRICATIONS.

I. Section 07 60 00, FLASHING AND SHEET METAL: Flashing for Wall and Roof Penetrations.

J. Section 07 84 00, FIRESTOPPING.

K. Section 07 92 00, JOINT SEALANTS.

L. Section 09 91 00, PAINTING.

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

N. Section 22 07 11, PLUMBING INSULATION.

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

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

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

R. Section 26 29 11, MOTOR CONTROLLERS.

**1.3 APPLICABLE PUBLICATIONS**

***Note: From the date contract documents are provided, the Contractor shall use the most current published versions of all listed standards and references below.**

A. The publications listed below will 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):

ASME Boiler and Pressure Vessel Code -

BPVC Section IX..... Welding, Brazing, and Fusing Qualifications

C. American Society for Testing and Materials (ASTM):

A36/A36M.....Standard Specification for Carbon Structural Steel

A575-96.....Standard Specification for Steel Bars, Carbon, Merchant Quality, M-Grades

E84 .....Standard Test Method for Surface Burning Characteristics of Building Materials

E119 .....Standard Test Methods for Fire Tests of Building Construction and Materials

D. International Code Council, (ICC):

IBC .....International Building Code

IPC .....International Plumbing Code

E. Manufacturers Standardization Society (MSS) of the Valve and Fittings Industry, Inc:

SP-58 .....Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application and Installation

F. Military Specifications (MIL):

P-21035B.....Paint High Zinc Dust Content, Galvanizing Repair (Metric)

G. National Electrical Manufacturers Association (NEMA):

MG 1.....Motors and Generators

H. National Fire Protection Association (NFPA):

51B .....Standard for Fire Prevention During Welding, Cutting and Other Hot Work

70 .....National Electrical Code (NEC)

99 .....Healthcare Facilities Code

I. NSF International (NSF):

14 .....Plastic Piping System Components and Related Materials

61 .....Drinking Water System Components – Health Effects

372 .....Drinking Water System Components – Lead Content

J. Department of Veterans Affairs (VA):

PG-18-10 .....Plumbing Design Manual

PG-18-13 .....Barrier Free Design Guide

**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 05 11, COMMON WORK RESULTS FOR PLUMBING", with applicable paragraph identification.

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

D. Contractor will 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 accessable 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 will 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 will 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 will 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, will 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 will be submitted under the pertinent section rather than under this section.
   1. Materials identification.
   2. Firestopping materials.
   3. Hangers, inserts, supports and bracing. Provide load calculations for variable spring and constant support hangers.
   4. 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 will include plan views, elevations and sections of all systems and will 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 will 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. 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.

**1.5 QUALITY ASSURANCE**

A. Mechanical, electrical, and associated systems will 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 will 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 will be experienced and qualified specialists in industrial and institutional plumbing.

B. Products Criteria:

1. Standard Products: Material and equipment will be the standard products of a manufacturer regularly engaged in the manufacture, supply and servicing of the specified products for at least 5 years. However, digital electronics devices, software and systems such as controls, instruments, computer work station, will be the current generation of technology and basic design that has a proven satisfactory service record of at least 5 years.
2. Equipment Service: There will be permanent service organizations, authorized and trained by manufacturers of the equipment supplied, located within 160 km (100 miles) of the project. These organizations will come to the site and provide acceptable service to restore operations within 4 hours of receipt of notification by phone, e-mail or fax in event of an emergency, such as the shut-down of equipment; or within 24 hours in a non-emergency. Names, mail and e-mail addresses and phone numbers of service organizations providing service under these conditions for (as applicable to the project): pumps, compressors, water heaters, critical instrumentation, computer workstation and programming will be submitted for project record and inserted into the operations and maintenance manual.
3. All items furnished will 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 will conform to the referenced codes and standards as required by the specifications. Local codes and amendments enforced by the local code official will be enforced, if required by local authorities such as the natural gas supplier. If the local codes are more stringent, then the local code will apply. Any conflicts will be brought to the attention of the Contracting Officers Representative (COR).
5. Multiple Units: When two or more units of materials or equipment of the same type or class are required, these units will be of the same manufacturer and model number, or if

different models are required they will 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 will be the responsibility of the manufacturer of the completed assembly.
7. Nameplates: Nameplate bearing manufacturer's name or identifiable trademark will 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. Asbestos products or equipment or materials containing asbestos is prohibited.
9. 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.

C. Welding: Before any welding is performed, Contractor will 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 will 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 will 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 will be applied and installed in accordance with manufacturer's written instructions. Conflicts between the manufacturer's instructions and the contract documents will be referred to the COR for resolution. Printed copies or electronic files of

manufacturer's installation instructions will be provided to the COR at least 10 working days prior to commencing installation of any item.

2. All items that require access, such as for operating, cleaning, servicing, maintenance, and calibration, will 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, and control devices. Prior to commencing installation work, refer conflicts between this requirement and contract documents to COR for resolution. Failure of the Contractor to resolve or call attention to any discrepancies or deficiencies to the COR will result in the Contractor correcting at no additional cost or time to the Government.
3. Installer Qualifications: Installer will be licensed and will 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. 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 will be removed and done again at no additional cost or time to the Government.

F. 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.

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

H. 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 will be considered mandatory, the word "should" will be interpreted as "will". Reference to the "code official" or "owner" will be interpreted to mean the COR.

I. Cleanliness of Piping and Equipment Systems:

1. Care will 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 will be removed.
2. Piping systems will be flushed, blown or pigged as necessary to deliver clean systems.
3. The interior of all tanks will be cleaned prior to delivery and beneficial use by the Government. All piping will be tested in accordance with the specifications and the

International Plumbing Code (IPC). All filters, strainers, fixture faucets will be flushed of debris prior to final acceptance.

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

**1.6 DELIVERY, STORAGE AND HANDLING**

A. Protection of Equipment:

1. Equipment and material placed on the job site will 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. Damaged equipment will be replaced with an identical unit as determined and directed by the COR. Such replacement will be at no additional cost or additional time to the Government.
3. Interiors of new equipment and piping systems will be protected against entry of foreign matter. Both inside and outside will be cleaned before painting or placing equipment in operation.
4. Existing equipment and piping being worked on by the Contractor will be under the custody and responsibility of the Contractor and will be protected as required for new work.
5. Protect plastic piping and tanks from ultraviolet light (sunlight) while in pre-construction. Plastic piping and tanks will not be installed exposed to sunlight without metal jacketing to block ultraviolet rays.

**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, VA approved substitutions and construction revisions will 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 will be included in the operation and maintenance manual. The operations and maintenance manual will include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices will be included. A List of recommended spare parts (manufacturer, model number, and quantity)

will be furnished. Information explaining any special knowledge or tools the owner will be required to employ will be inserted into the As-Built documentation.

C. The installing Contractor will maintain as-built drawings of each completed phase for verification; and, will 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 will not be deemed a conflict of interest or breach of the 'third party testing company' requirement. Provide record drawings as follows:
   1. Red-lined, hand-marked drawings are to be provided, with one paper copy and a scanned PDF version of the hand-marked drawings provided on CD or DVD.

**1.8 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 VAMC.

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

C. Phasing of Work: Comply with all requirements shown on contract documents. Contractor will submit a complete detailed phasing plan/schedule with manpower levels prior to commencing work. The phasing plan will be detailed enough to provide milestones in the process that can be verified.

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. 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.

E. 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 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. Temporary Facilities: Refer to Paragraph, TEMPORARY PIPING AND EQUIPMENT in this section.

**PART 2 - PRODUCTS**

**2.1 MATERIALS FOR VARIOUS SERVICES**

A. Steel pipe will contain a minimum of 25 percent recycled content.

B. Material or equipment containing a weighted average of greater than 0.25 percent lead will not be used in any potable water system intended for human consumption and will be certified in accordance with NSF 61 or NSF 372.

C. In-line devices such as water meters, building valves, check valves, stops, valves, fittings, tanks and backflow preventers will comply with NSF 61 and NSF 372.

**2.2 FACTORY-ASSEMBLED PRODUCTS**

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

B. Manufacturers of equipment assemblies that include components made by others will 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 will be products of a single manufacturer.
3. Components will be compatible with each other and with the total assembly for intended service.
4. Contractor will guarantee performance of assemblies of components and will repair or replace elements of the assemblies as required to deliver specified performance of the complete assembly at no additional cost or time to the Government.

C. Components of equipment will 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, will be the same make and model.

**2.3 COMPATIBILITY OF RELATED EQUIPMENT**

A. Equipment and materials installed will 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**

A. Pump shafts and couplings will be fully guarded by a sheet steel guard, covering coupling and shaft but not bearings. Material will be minimum 16-gauge sheet steel; ends will be braked and

drilled and attached to pump base with minimum of four 8 mm (1/4 inch) bolts. Reinforce guard as necessary to prevent side play forcing guard onto couplings.

**2.5**

A. All equipment will have moving parts protected from personal injury.

**2.6 LIFTING ATTACHMENTS**

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

B. All material and equipment furnished and installation methods used will conform to the requirements of Section 22 05 12, GENERAL MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT; Section 26 29 11, MOTOR CONTROLLERS; and, Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES. All electrical wiring, conduit, and devices necessary for the proper connection, protection and operation of the systems will be provided. Premium efficient motors will be provided. Unless otherwise specified for a particular application, electric motors will have the following requirements.

C. 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 at no additional cost or time to the Government.
2. Assemblies of motors, starters, and controls and interlocks on factory assembled and wired devices will be in accordance with the requirements of this specification.
3. Wire and cable materials specified in the electrical division of the specifications will be modified as follows:
    a. Wiring material located where temperatures can exceed 71° C (160° F) will be stranded copper with Teflon FEP insulation with jacket. This includes wiring on the boilers and water heaters.
    b. Other wiring at boilers and water heaters, and to control panels, will be NFPA 70 designation THWN.
    c. Shielded conductors or wiring in separate conduits for all instrumentation and control systems will be provided where recommended by manufacturer of equipment.

4. Motor sizes will be selected so that the motors do not operate into the service factor at maximum required loads on the driven equipment. Motors on pumps will be sized for non-overloading at all points on the pump performance curves.
5. Motors utilized with variable frequency drives will be rated “inverter-ready” per NEMA Standard, MG1.

D. Motor Efficiency and Power Factor: All motors, when specified as “high efficiency or Premium Efficiency” by the project specifications on driven equipment, will conform to efficiency and power factor requirements in Section 22 05 12, GENERAL MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT, with no consideration of annual service hours. Motor manufacturers generally define these efficiency requirements as “NEMA premium efficient” and the requirements generally exceed those of the Energy Policy Act (EPACT), revised 2005. Motors not specified as “high efficiency or premium efficient” will comply with EPACT.

E. Single-phase Motors: Capacitor-start type for hard starting applications. Motors for centrifugal pumps may be split phase or permanent split capacitor (PSC).

F. Poly-phase Motors: NEMA Design B, Squirrel cage, induction type. Each two-speed motor will have two separate windings. A time delay (20 seconds minimum) relay will be provided for switching from high to low speed.

G. Rating: Rating will be continuous duty at 100 percent capacity in an ambient temperature of 40° C (104° F); minimum horsepower as shown on drawings; maximum horsepower in normal operation will not exceed nameplate rating without service factor.

H. Insulation Resistance: Not less than one-half meg-ohm between stator conductors and frame will be measured at the time of final inspection.

**2.7 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. The combination of controller and motor will be provided by the respective pump manufacturer and will be rated for 100 percent output performance. Multiple units of the same class of equipment, i.e. pumps, will be product of a single manufacturer.

C. Motors will be premium efficient type, “invertor duty”, and be approved by the motor controller manufacturer. The controller-motor combination will be guaranteed to provide full motor nameplate horsepower in variable frequency operation. Both driving and driven motor sheaves will be fixed pitch.

D. Controller will not add any current or voltage transients to the input AC power distribution system, DDC controls, sensitive medical equipment, etc., nor will be affected from other devices on the AC power system.

**2.8 EQUIPMENT AND MATERIALS IDENTIFICATION**

A. Use symbols, nomenclature and equipment numbers specified, shown in the drawings, or shown in the maintenance manuals. Coordinate equipment and valve identification with local VAMC shops. In addition, provide bar code identification nameplate for all equipment which will allow the equipment identification code to be scanned into the system for maintenance and inventory tracking. Identification for piping is specified in Section 09 91 00, PAINTING.

B. Interior (Indoor) Equipment: Engraved nameplates, with letters not less than 7 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 will be permanently fastened to the equipment. Unit components such as water heaters, tanks, coils, filters, etc. will be identified.

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

D. Valve Tags and Lists:

1. Plumbing: All valves will 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 15 mm (1/2 inch) high for number designation, and not less than 8 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: Valve lists will be created using a word processing program and printed on plastic coated cards. The plastic-coated valve list card(s), sized 215 mm (8-1/2 inches) by 275 mm (11 inches) will show valve tag number, valve function and area of control for each service or system. The valve list will be in a punched 3-ring binder notebook. An additional copy of the valve list will be mounted in picture frames for mounting to a wall. COR will instruct Contractor where frames will be mounted.
4. A detailed plan for each floor of the building indicating the location and valve number for each valve will be provided in the 3-ring binder notebook. Each valve location will be identified with a color-coded sticker or thumb tack in ceiling or access door.

**2.9 FIRESTOPPING**

A. Section 07 84 00, FIRESTOPPING specifies an effective barrier against the spread of fire, smoke and gases where penetrations occur for piping. Refer to Section 22 07 11, PLUMBING INSULATION, for pipe insulation.

**2.10 GALVANIZED REPAIR COMPOUND**

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

**2.11 PIPE AND EQUIPMENT SUPPORTS AND RESTRAINTS**

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

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. Attachment to Metal Pan or Deck: As required for materials specified in Section 05 31 00, STEEL DECKINGand Section 05 36 00, COMPOSITE METAL DECKING.

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

F. 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 will provide 40 mm (1-1/2 inches) minimum of adjustment and incorporate locknuts. All-thread rods are acceptable.

G. Multiple (Trapeze) Hangers: Galvanized, cold formed, lipped steel channel horizontal member, not less than 43 mm by 43 mm (1-5/8 inches by 1-5/8 inches), 2.7 mm (No. 12 gauge), designed to accept special spring held, hardened steel nuts.
   1. Allowable hanger load: Manufacturers rating less 91kg (200 pounds).

2. Guide individual pipes on the horizontal member of every other trapeze hanger with 8 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 insulated calcium silicate shield for insulated piping at each hanger.

H. 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 will be painted with copper colored epoxy paint, copper-coated, plastic coated or taped with isolation tape to prevent electrolysis.
        2) For vertical runs use epoxy painted, copper-coated 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. Spring hangers are required on all plumbing system pumps one horsepower and greater.
2. Plumbing Piping (Other Than General Types):
    a. Horizontal piping: Type 1, 5, 7, 9, and 10.
    b. Chrome plated piping: Chrome plated supports.
    c. Hangers and supports in pipe chase: Prefabricated system ABS self-extinguishing material, not subject to electrolytic action, to hold piping, prevent vibration and compensate for all static and operational conditions.

d. Blocking, stays and bracing: Angle iron or preformed metal channel shapes, 1.3 mm (18 gauge) minimum.

I. Pre-insulated Calcium Silicate Shields:

1. Provide 360-degree water resistant high density 965 kPa (140 psig) 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 will 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 will have insulation that extends a minimum of 25 mm (1 inch) past the sheet metal.
   b. The insulated calcium silicate shield will support the maximum allowable water filled span as indicated in MSS SP-58. To support the load, the shields will 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.
5. Shields may be used on steel clevis hanger type supports, trapeze hangers, roller supports or flat surfaces.

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

**2.12 PIPE PENETRATIONS**

A. Pipe penetration sleeves will be installed for all pipe other than rectangular blocked out floor openings for risers in mechanical bays.

B. Pipe penetration sleeve materials will comply with all firestopping 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 prohibited through beams or ribs, but may be installed in concrete beam flanges, with structural engineer prior approval. Any deviation from these requirements must receive prior approval of COR.

E. Sheet metal, plastic, or moisture resistant fiber sleeves will 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 will be provided for pipe passing through exterior walls below grade. The space between the sleeve and pipe will be made watertight with a modular or link rubber seal. The link seal will be applied at both ends of the sleeve.

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

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

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

J. Sealant and Adhesives: Will be as specified in Section 07 92 00, JOINT SEALANTS. Bio-based materials will be utilized when possible.

K. Pipe passing through roof will be installed through a 4.9 kg per square meter copper flashing with an integral skirt or flange. Skirt or flange will extend not less than 200 mm (8 inches) from the pipe and set in a solid coating of bituminous cement. Extend flashing a minimum of 250 mm (10 inches) up the pipe. Pipe passing through a waterproofing membrane will be provided with a clamping flange. The annular space between the sleeve and pipe will be sealed watertight.

**2.13 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. Bio-based materials will be utilized when possible.

**2.14 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 75 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 will be used where insulation ends on exposed water supply pipe drop from overhead. A watertight joint will be provided in spaces where brass or steel pipe sleeves are specified.

**2.15 ASBESTOS**

A. Materials containing asbestos are prohibited.

**PART 3 - EXECUTION**

**3.1 ARRANGEMENT AND INSTALLATION OF EQUIPMENT AND PIPING**

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

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

C. Operating Personnel Access and Observation Provisions: All equipment and systems will be arranged to provide clear view and easy access, without use of portable ladders, for maintenance, testing and operation of all devices including, but not limited to: all equipment items, valves, backflow preventers, filters, strainers, transmitters, sensors, meters and control

devices. All gauges and indicators will be clearly visible by personnel standing on the floor or on permanent platforms. Maintenance and operating space and access provisions that are shown in the drawings will not be changed nor reduced.

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

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

F. Cutting Holes:

1. Holes will be located to avoid interference with structural members such as beams or grade beams. Holes will 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 will be referred to COR for approval.
2. Waterproof membrane will not be penetrated. Pipe floor penetration block outs will be provided outside the extents of the waterproof membrane.
3. Holes through concrete and masonry will 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.

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

H. Protection and Cleaning:

1. Equipment and materials will 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, will be replaced at no additional cost or time to the Government.
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 will 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 psig) minimum, specified in Section 03 30 00, CAST-IN-PLACE CONCRETE, will be used for all pad or floor mounted equipment.

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

K. Interconnection of Controls and Instruments: Electrical interconnection is generally not shown but will be provided. This includes interconnections of sensors, transmitters, transducers, control devices, control and instrumentation panels, alarms, instruments and computer workstations. Comply with NFPA 70.

L. Domestic cold and hot water systems interface with the HVAC control system for the temperature, pressure and flow monitoring requirements to mitigate legionella. See the HVAC control points list and Section 23 09 23, DIRECT DIGITAL CONTROL SYSTEM FOR HVAC.

M. 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.

N. Work in bathrooms, restrooms, housekeeping closets: All pipe penetrations behind escutcheons will be sealed with plumbers’ putty.

O. Switchgear Drip Protection: Every effort will be made to eliminate the installation of pipe above data equipment, and electrical and telephone switchgear. If this is not possible, encase pipe in a second pipe with a minimum of joints. Drain valve will be provided in low point of casement pipe.

P. Inaccessible Equipment:

1. Where the Government determines that the Contractor has installed equipment not conveniently accessible for operation and maintenance, equipment will be removed and reinstalled or remedial action performed as directed at no additional cost or additional time 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 electrical

conduit, motors, fans, pumps, belt guards, transformers, high voltage lines, piping, and ductwork.

**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 will be provided to maintain continuity of operation of existing facilities.

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

C. Temporary facilities and piping will be completely removed back to the nearest active distribution branch or main pipe line and any openings in structures sealed. Dead legs are prohibited in potable water systems. Necessary blind flanges and caps will be provided to seal open piping remaining in service.

**3.3 RIGGING**

A. Openings in building structures will 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 will be closed when not required for rigging operations to maintain proper environment in the facility for Government operation and maintenance of service.

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

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

F. Rigging plan and methods will 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 will 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 will not be permitted. Rusty products will be replaced.

C. Hanger rods will 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 will be provided.

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

E. 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 will be supported in channel troughs.

F. 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 will be anchored and doweled to resist forces under operating and seismic conditions (if applicable) without excessive displacement or structural failure.
2. Bases and supports will not be located and installed until equipment mounted thereon has been approved. Bases will be sized to match equipment mounted thereon plus 50 mm (2 inch) excess on all edges. Structural drawings will be reviewed for additional requirements. Bases will be neatly finished and smoothed, will have chamfered edges at the top, and will be suitable for painting.
3. All equipment will be shimmed, leveled, firmly anchored, and grouted with epoxy grout. Anchor bolts will 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 will be lubricated prior to initial operation. All devices and equipment will be field checked for proper lubrication.

B. All devices and equipment will be equipped with required lubrication fittings. A minimum of 1 liter (1 quart) of oil and 0.45 kg (1 pound) of grease of manufacturer's recommended grade and type for each different application will be provided. All materials will be delivered to COR in unopened containers that are properly identified as to application.

C. A separate grease gun with attachments for applicable fittings will be provided for each type of grease applied.

D. All lubrication points will be accessible without disassembling equipment, except to remove access plates.

E. All lubrication points will be extended to one side of the equipment.

**3.6 PLUMBING SYSTEMS DEMOLITION**

A. Rigging access, other than indicated in the drawings, will be provided after approval for structural integrity by the COR. Such access will be provided at no additional cost or time to the Government. Where work is in an operating plant, approved protection from dust and debris will be provided at all times for the safety of plant personnel and maintenance of plant operation and environment of the plant.

B. In an operating facility, cleanliness and safety will be maintained. The facilitywill be kept in an operating condition. Government personnel will be carrying on their normal duties of operating, cleaning and maintaining equipment and facilityoperation. Work will be confined to the immediate area concerned; maintain cleanliness and wet down demolished materials to eliminate dust. Dust and debris will not be permitted to accumulate in the area to the detriment of facility operation. All flame cutting will be performed to maintain the fire safety integrity of this facility. Adequate fire extinguishing facilities will be available at all times. All work will be performed in accordance with recognized fire protection standards including NFPA 51B. Inspections will be made by personnel of the VAMC, and the Contractor will 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 will 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 will 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 will be maintained. Reference will also be made to the drawings and specifications of the other disciplines in the project for additional facilities to be demolished or handled.

D. All valves including gate, globe, ball, butterfly and check, all pressure gauges and thermometers with wells will remain Government property and will be removed and delivered to COR and stored as directed. The Contractor will remove all other material and equipment, devices and demolition debris under these plans and specifications. Such material will be removed from Government property expeditiously and will not be allowed to accumulate. Coordinate with the COR and Infection Control.

E. Asbestos Insulation Removal: Conform to Section 02 82 11, TRADITIONAL ASBESTOS ABATEMENT.

**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 will be thoroughly cleaned and painted. Refer to Section 09 91 00, PAINTING.

B. In addition, the following special conditions apply:

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

j. Glass.

k. Name plates.

3. Pumps, motors, steel and cast-iron bases, and coupling guards will be cleaned, and will be touched-up with the same paint type and color as utilized by the pump manufacturer.
4. The final result will be a smooth, even-colored, even-textured factory finish on all items. The entire piece of equipment will be repainted, if necessary, to achieve this. Lead based paints will not be used.

**3.8 IDENTIFICATION SIGNS**

A. Laminated plastic signs, with engraved lettering not less than 7 mm (3/16 inch) high, will be provided that designates equipment function, for all equipment, switches, motor controllers, relays, meters, control devices, including automatic control valves. Nomenclature and identification symbols will 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, and performance data will be placed on factory-built equipment.

C. Pipe Identification: Refer to Section 09 91 00, PAINTING.

**3.9 STARTUP AND TEMPORARY OPERATION**

A. Startup of equipment will be performed as described in the equipment specifications. Vibration within specified tolerance will 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.

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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.

B. A complete listing of common 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 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.

D. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

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

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

**1.3 APPLICABLE PUBLICATIONS**

***Note: From the date contract documents are provided, the Contractor shall use the most current published versions of all listed standards and references below.**

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):

A112.14.1 ..... Backwater Valves

C. American Society of Sanitary Engineering (ASSE):

1001 ..... Performance Requirements for Atmospheric Type Vacuum Breakers

1003 ..... Performance Requirements for Water Pressure Reducing Valves for Domestic Water Distribution Systems

1011 ..... Performance Requirements for Hose Connection Vacuum Breakers

1013 ..... Performance Requirements for Reduced Pressure Principle Backflow Preventers and Reduced Pressure Principle Fire Protection Backflow Preventers

1015 ..... Performance Requirements for Double Check Backflow Prevention Assemblies and Double Check Fire Protection Backflow Prevention Assemblies

1017 ..... Performance Requirements for Temperature Actuated Mixing Valves for Hot Water Distribution Systems

1020 ..... Performance Requirements for Pressure Vacuum Breaker Assembly

1035 ..... Performance Requirements for Laboratory Faucet Backflow Preventers

1069 ..... Performance Requirements for Automatic Temperature Control Mixing Valves

1070 ..... Performance Requirements for Water Temperature Limiting Devices

1071 ..... Performance Requirements for Temperature Actuated Mixing Valves for Plumbed Emergency Equipment

D. American Society for Testing and Materials (ASTM):

A126-2004..... Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings

A276/A276M..... Standard Specification for Stainless Steel Bars and Shapes

A536-1984..... Standard Specification for Ductile Iron Castings

B62 ..... Standard Specification for Composition Bronze or Ounce Metal Castings

B584 ..... Standard Specification for Copper Alloy Sand Castings for General Applications

E. International Code Council (ICC):

IPC ..... International Plumbing Code

F. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS):

SP-25 ..... Standard Marking Systems for Valves, Fittings, Flanges and Unions

SP-67 ..... Butterfly Valves

SP-70 ..... Gray Iron Gate Valves, Flanged and Threaded Ends

SP-71 ..... Gray Iron Swing Check Valves, Flanged and Threaded Ends

SP-80 .....Bronze Gate, Globe, Angle, and Check Valves

SP-85 .....Gray Iron Globe & Angle Valves, Flanged and Threaded Ends

SP-110 .....Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends

G. National Environmental Balancing Bureau (NEBB):

8th Edition Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems

H. NSF International (NSF):

61 .....Drinking Water System Components – Health Effects

372 .....Drinking Water System Components – Lead Content

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

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

**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. Gate Valves.
3. Butterfly Valves.
4. Balancing Valves.
5. Check Valves.
6. Globe Valves.
7. Water Pressure Reducing Valves and Connections.
8. Backwater Valves.
9. Backflow Preventers.
10. Chainwheels.

11. Thermostatic Mixing Valves.

D. Test and Balance reports for balancing valves.

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.
4. Piping diagrams of thermostatic mixing valves to be installed.

**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 angle, gate, and globe valves closed to prevent rattling.
4. Set ball and plug valves open to minimize exposure of functional surfaces.
5. Set butterfly valves closed or slightly open.
6. 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.

C. A sling shall be used for large valves. The sling shall be rigged to avoid damage to exposed parts. Hand wheels or stems shall not be used as lifting or rigging points.

**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. Exposed Valves over 65 mm or DN65 (2-1/2 inches) installed at an elevation over 3.6 m (12 feet) shall have a chain-wheel attachment to valve hand-wheel, stem, or other actuator.

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

F. 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.

G. Refer to Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS for additional sustainable design requirements.

**2.2 SHUT-OFF VALVES**

A. Cold, Hot and Re-circulating Hot 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. 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.
3. 100 mm DN100 (4 inches) and greater:
    a. Class 125, OS&Y, Cast Iron Gate Valve. The gate valve shall meet MSS SP-70 type I standard. The gate valve shall have a CWP rating of 1380 kPa (200 psig). The valve materials shall meet ASTM A126, grey iron with bolted bonnet, flanged ends, bronze trim, and positive-seal resilient solid wedge disc. The gate valve shall be gear operated for sizes under 200 mm or DN200 (8 inches) and crank operated for sizes 200 mm or DN200 (8 inches) and greater.

b. Single flange, ductile iron butterfly valves: The single flanged butterfly valve shall meet the MSS SP-67 standard. The butterfly valve shall have a CWP rating of 1380 kPa (200 psig). The butterfly valve shall be lug type, suitable for bidirectional dead-end service at rated pressure without use of downstream flange. The body material shall comply with ASTM A536 ductile iron. The seat shall be EPDM with stainless steel disc and stem.

c. Grooved end, ductile iron butterfly valves. The grooved butterfly valve shall meet the MSS SP-67 standard. The grooved butterfly valve shall have a CWP rating of 1380 kPa (200 psig). The valve materials shall be epoxy coated ductile iron conforming to ASTM A536 with two-piece stainless-steel stem, EPDM encapsulated ductile iron disc, and EPDM seal. The butterfly valve shall be gear operated.

B. Reagent Grade Water: Valves for reagent grade, reverse osmosis, or deionized water service shall be ball type of same material as used for pipe.

**2.3 CHECK VALVES**

A. 75 mm or DN75 (3 inches) and smaller shall be Class 125, bronze swing check valves with non-metallic disc suitable for type of service. 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 B62, solder joints, and PTFE or TFE disc.

B. 100 mm or DN100 (4 inches) and greater:

1. Check valves shall be Class 125, iron swing check valve with lever and weight closure control. The check valve shall meet MSS SP-71 Type I standard. The check valve shall have a CWP rating of 1380 kPa (200 psig). The check valve shall have a clear or full waterway body design with gray iron body material conforming to ASTM A126, bolted bonnet, flanged ends, bronze trim.
2. All check valves on the discharge side of submersible sump pumps shall have factory installed exterior level and weight with sufficient weight to prevent the check valve from hammering against the seat when the sump pump stops.

**2.4 GLOBE VALVES**

A. 75 mm or DN75 (3 inches) or smaller: Class 150, bronze globe valve with non-metallic disc. The globe valve shall meet MSS SP-80, Type 2 standard. The globe valve shall have a CWP rating of 2070 kPa (300 psig). The valve material shall be bronze with integral seal and union ring bonnet

conforming to ASTM B62 with solder ends, copper-silicon bronze stem, PTFE or TFE disc, and malleable iron hand wheel.

B. Greater than 75 mm or DN75 (3 inches): Similar to above, except with cast iron body and bronze trim, Class 125, iron globe valve. The globe valve shall meet MSS SP-85, Type 1 standard. The globe valve shall have a CWP rating of 1380 kPa (200 psig). The valve material shall be gray iron with bolted bonnet conforming to ASTM A126 with flanged ends, bronze trim, and malleable iron handwheel.

**2.5 WATER PRESSURE REDUCING VALVE AND CONNECTIONS**

A. 75 mm or DN75 (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 pressure reducing valve shall meet ASSE 1003. 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. 100 mm or DN100 (4 inches) and greater: The pressure reducing valve shall consist of a flanged cast iron body and rated to 1380 kPa (200 psig). The valve shall have a large elastomer diaphragm for sensitive response. The pressure reducing valve shall meet ASSE 1003.

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

D. The regulator shall have a temperature rating of 100 degrees C (212 degrees F) for hot water or hot water return service. Pressure regulators shall have accurate pressure regulation to 6.9 kPa (+/- 1 psig).

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

F. 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 gauge shall be installed on the inlet and outlet of the valve.

**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 approved by the University of Southern California Foundation for Cross Connection Control and Hydraulic Research (USCFCCC).

B. The reduced pressure principle backflow prevention assembly shall be ASSE listed 1013 with full port OS&Y positive-seal resilient gate valves and an integral relief monitor switch. The main body and access cover shall be epoxy coated ductile iron conforming to ASTM A536 grade 4. The seat ring and check valve shall be the thermoplastic type suited for water service. The stem shall be stainless steel conforming to ASTM A276/A276M. The seat disc shall be the elastomer type suited for water service. 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. Reduced pressure backflow preventers shall be installed in the following applications.
   1. Water make up to heating systems.
   2. Process equipment.

C. Automatic Water Temperature Control Mixing Valves:
   1. Application: Gang plumbing fixtures point-of-use when no other mixing at fixtures occurs.
   2. Standard: ASSE 1069.
   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 or soldered inlets and outlet.
   6. Thermometers shall be provided to indicate mixed water temperature.
   7. Upon cold water supply failure the hot water flow shall automatically be reduced to 0.5 gpm maximum.
   8. Provide a high temperature alarm device to detect mixing valve failure.

D. 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 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 and on top of valve.

F. Install pressure gauges on outlet of backflow preventers.

G. Do not install bypass piping around backflow preventers.

H. Install temperature-actuated water mixing valves with check stops or shutoff valves on inlets.

1. Install thermometers if specified.
2. Install cabinet-type units recessed in or surface mounted on wall as specified.

I. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no additional cost or time to the Government.

**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.

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. 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 VA Contracting Officer's Representative (COR).

**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.

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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 common 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 13, 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 26 05 19, LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES.

**1.3 APPLICABLE PUBLICATIONS**

***Note: From the date contract documents are provided, the Contractor shall use the most current published versions of all listed standards and references below.**

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

515.1 .....Testing, Design, Installation, and Maintenance of Electrical Resistance Trace Heating for Commercial Applications

C. International Code Council, (ICC):

IPC .....International Plumbing Code

D. National Fire Protection Association (NFPA):

70 .....National Electrical Code (NEC)

E. Underwriters' Laboratories, Inc. (UL):

508 .....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.

D. 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.

E. Field quality control test reports shall be submitted.

F. Complete operating and maintenance manuals including wiring diagram, technical data sheets, information for ordering replaceable parts, and troubleshoot 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.

**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 or tank 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.

C. 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.

D. 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.

E. Refer to Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS for additional sustainable design requirements.

**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 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 high melt viscosity PVDE (Polyvinylidene Fluoride) 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).

F. The capacities and characteristics shall be:
   1. Maximum heat output 19.7 W/m (6 W/foot).

2. Number of parallel cables: 1.
3. See electrical drawings for electrical characteristics.

**2.2 CONSTANT WATTAGE RESISTANCE HEATING CABLES**

A. Constant Wattage Resistance Heating Cables shall comply with IEEE 515.1.

B. The heating element shall be a pair of parallel No. 12 AWG, tinnedstranded copper bus wires with single stranded resistor wire connected between bus wires. The heating element shall be terminated with waterproof, factory assembled non-heating leads with connectors at one end and seal the opposite end watertight.

C. The electrical insulating jacket shall be flame retardant fluoropolymer.

D. The cable cover shall be stainless steel braid and polyolefin outer jacket with UV inhibitor.

E. The maximum operating temperature shall be 200 degrees C (392 degrees F).

F. The maximum exposure temperature shall be 200 degrees C (392 degrees F).

G. The capacities and characteristics shall be:

1. Maximum heat output 13.1 W/m (4.0 W/foot).
2. See electrical drawings for electrical characteristics.

**2.3 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 (34 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. The control enclosure shall be corrosion resistant and waterproof.

B. The precipitation and temperature sensor for snow melting on roofs and in gutters shall be automatic based control with manual on, automatic, and standby/reset switches. The precipitation and temperature sensors shall sense the surface conditions of roof and/or gutters and shall be programmed to energize the cable as follows:

1. Temperature span between 1 to 7 degrees C (34 to 44 degrees F).
2. Adjustable delay off span between 30 and 90 minutes.
3. Following a two minute delay, the cables shall be energized if ambient temperature is below set-point and precipitation is detected.
4. The cables shall be de-energized upon detection of a dry surface plus a time delay of 15 minutes.

C. The enclosure shall be the NEMA 4X type.

D. A minimum 30 amp contactor shall be provided to energize cable or close other contactors. Provide relay with contacts to indicate operational status, on/off, and for interface with central energy management and control system.

**2.4 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 Warning Tape on Pipes with Outside Dimension, Including Insulation, Less Than 150 mm (6 inches): 19 mm (3/4 inch) minimum.
2. Width for Warning Tape on Pipes with Outside Dimension, Including Insulation, 150 mm (6 inches) or Greater: 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 additional cost or time to the Government.

**3.2 INSTALLATION**

A. Electric heating cable shall be installed for the following applications:

1. Snow and ice melting on roofs, in gutters and downspouts, roof drain bodies, and roof drain leaders: Plastic-insulated series-resistanceConstant-wattage resistance heating cable.
2. Freeze protection of plumbing piping: Plastic-insulated series-resistanceConstant-wattage 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.
5. Provide current transducer to monitor power in heating tape and monitor and alarm from BAS.

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 :

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 addition cost or time to the Government.

E. Prepare test and inspection reports.

**3.4 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.

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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 the following:
   1. Plumbing piping and equipment.

B. Definitions:
   1. ASJ: All Service Jacket, Kraft paper, white finish facing or jacket.
   2. Air conditioned space: Space having air temperature and/or humidity controlled by mechanical equipment.
   3. All insulation systems installed within supply, return, exhaust, relief and ventilation air plenums shall be limited to uninhabited crawl spaces, areas above a ceiling or below the floor, attic spaces, interiors of air conditioned or heating ducts, and mechanical equipment rooms shall be noncombustible or shall be listed and labeled as having a flame spread indexes of not more than 25 and a smoke-developed index of not more than 50 when tested in accordance with ASTM E84 or UL 723. Note: ICC IMC, Section 602.2.1.
   4. Cold: Equipment or piping handling media at design temperature of 15 degrees C (60 degrees F) or below.
   5. Concealed: Piping above ceilings and in chases, and pipe spaces.
   6. Exposed: Piping and equipment exposed to view in finished areas including mechanical equipment rooms or exposed to outdoor weather. Shafts, chases, unfinished attics, crawl spaces and pipe basements are not considered finished areas.
   7. FSK: Foil-scrim-Kraft facing.
   8. Hot: Plumbing equipment or piping handling media above 40 degrees C (104 degrees F).
   9. Density: $kg/m^3$ - kilograms per cubic meter (Pcf - pounds per cubic foot).
   10. 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 linear meter (BTU per hour per linear foot) for a given outside diameter.
   11. Thermal Conductivity (k): Watts per meter, per degree K (BTU - 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/vapor barriers shall have a maximum published permeance of .02 perms.

13. HWR: Hot water recirculating.
14. CW: Cold water.
15. HW: Hot water.
16. PVDC: Polyvinylidene chloride vapor retarder jacketing, white.

**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 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS: Insulation material and insulation production method.
D. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.
E. Section 02 82 11, TRADITIONAL ASBESTOS ABATEMENT: Insulation containing asbestos material.
F. Section 07 84 00, FIRESTOPPING: Mineral fiber and bond breaker behind sealant.
G. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING: General mechanical requirements and items, which are common to more than one section of Division 22.
H. Section 22 05 19, METERS AND GAGES FOR PLUMBING PIPING: Hot and cold water piping.
I. Section 22 05 23, GENERAL-DUTY VALVES FOR PLUMBING PIPING: Hot and cold water piping.
J. Section 22 05 33, HEAT TRACING FOR PLUMBING PIPING: Insulation over heating cables.
K. Section 23 21 13, HYDRONIC PIPING: electrical heat tracing systems.

**1.3 APPLICABLE PUBLICATIONS**

***Note: From the date contract documents are provided, the Contractor shall use the most current published versions of all listed standards and references below.**

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. American Society for Testing and Materials (ASTM):

B209 .....Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
C411 .....Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation
C449-2007 .....Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement

C450-2008 .....Standard Practice for Fabrication of Thermal Insulating Fitting Covers for NPS Piping, and Vessel Lagging

Adjunct to C450 .....Compilation of Tables that Provide Recommended Dimensions for Prefab and Field Thermal Insulating Covers, etc.

C533 .....Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation

C534/C534M .....Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form

C547 .....Standard Specification for Mineral Fiber Pipe Insulation

C552 .....Standard Specification for Cellular Glass Thermal Insulation

C553 .....Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications

C591 .....Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation

C680 .....Standard Practice for Estimate of the Heat Gain or Loss and the Surface Temperatures of Insulated Flat, Cylindrical, and Spherical Systems by Use of Computer Programs

C612 .....Standard Specification for Mineral Fiber Block and Board Thermal Insulation

C1126 .....Standard Specification for Faced or Unfaced Rigid Cellular Phenolic Thermal Insulation

C1136 .....Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation

C1710 .....Standard Guide for Installation of Flexible Closed Cell Preformed Insulation in Tube and Sheet Form

D1668/D1668M .....Standard Specification for Glass Fabrics (Woven and Treated) for Roofing and Waterproofing

E84 .....Standard Test Method for Surface Burning Characteristics of Building Materials

E2231 .....Standard Practice for Specimen Preparation and Mounting of Pipe and Duct Insulation to Assess Surface Burning Characteristics

C. Federal Specifications (Fed. Spec.):

L-P-535E .....Plastic Sheet (Sheeting): Plastic Strip; Poly (Vinyl Chloride) and Poly (Vinyl Chloride - Vinyl Acetate), Rigid.

D. International Code Council, (ICC):

IMC.....International Mechanical Code

E. Military Specifications (Mil. Spec.):

MIL-A-3316C (2).....Adhesives, Fire-Resistant, Thermal Insulation

MIL-A-24179A (2).....Adhesive, Flexible Unicellular-Plastic Thermal Insulation

MIL-PRF-19565C (1) .....Coating Compounds, Thermal Insulation, Fire-and Water-Resistant, Vapor-Barrier

MIL-C-20079H .....Cloth, Glass; Tape, Textile Glass; and Thread, Glass and Wire-Reinforced Glass

F. National Fire Protection Association (NFPA):

90A.....Standard for the Installation of Air-Conditioning and Ventilating Systems

G. Underwriters Laboratories, Inc (UL):

723 .....Standard for Test for Surface Burning Characteristics of Building Materials

1887 .....Standard for Fire Test of Plastic Sprinkler Pipe for Visible Flame and Smoke Characteristics

H. 3E Plus® version 4.1 Insulation Thickness Computer Program: Available from NAIMA with free download; https://insulationinstitute.org/tools-resources/

**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 07 11, PLUMBING INSULATION”, 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. Shop Drawings:

1. All information, clearly presented, shall be included to determine compliance with drawings and specifications and ASTM Designation, Federal and Military specifications.
    a. Insulation materials: Specify each type used and state surface burning characteristics.
    b. Insulation facings and jackets: Each type used and state surface burning characteristics.
    c. Insulation accessory materials: Each type used.
    d. Manufacturer's installation and fitting fabrication instructions for flexible unicellular insulation shall follow the guidelines in accordance with ASTM C1710.
    e. Make reference to applicable specification paragraph numbers for coordination.
    f. All insulation fittings (exception flexible unicellular insulation) shall be fabricated in accordance with ASTM C450 and the referenced Adjunct to ASTM C450.

**1.5 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, 4.3.11.2.6, parts of which are quoted as follows:

    **4.3.3.1** Pipe and duct insulation and 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 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 ASTM E84 and appropriate mounting practice, e.g. ASTM E2231.

    **4.3.3.3** Coverings and linings for air ducts, pipes, plenums and panels including all pipe and duct insulation materials shall not flame, glow, smolder, or smoke when tested in accordance with a similar test for pipe covering, ASTM C411, Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation, at the temperature to which they are exposed in service. In no case shall the test temperature be below 121 degrees C (250 degrees F).

    **4.3.11.2.6.3** Nonferrous fire sprinkler piping 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 1887, Standard for Safety Fire Test of Plastic Sprinkler Pipe for Visible Flame and Smoke Characteristics.

**4.3.11.2.6.8** Smoke detectors shall not be required to meet the provisions of Section 4.3.

2. Test methods: ASTM E84, UL 723, and ASTM E2231.
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. 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 via electronic file transfer. One copy of operation and maintenance manuals 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.

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 2023 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 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.

**1.7 STORAGE AND HANDLING OF MATERIAL**

A. Store materials in clean and dry environment, pipe insulation 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.

**PART 2 - PRODUCTS**

**2.1 MINERAL FIBER OR FIBER GLASS**

A. ASTM C612 (Board, Block), Class 1 or 2, density 48 kg/$m^3$ (nominal 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/$m^3$ (nominal 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, k = 0.037 (0.26) at 24 degrees C (75 degrees F), for use at temperatures up to 230 degrees C (446 degrees F) with an all service vapor retarder jacket (ASJ) and with polyvinyl chloride (PVC) premolded fitting covering.

**2.2 CELLULAR GLASS CLOSED-CELL**

A. Comply with Standard ASTM C552, density 120 kg/$m^3$ (7.5 pcf) nominal, k = 0.033 (0.29) at 24 degrees C (75 degrees F).

B. Pipe insulation for use at process temperatures below ambient air to 482 degrees C (900 degrees F) with or without all service vapor retarder jacket (ASJ).

C. Pipe insulation for use at process temperatures for pipe and tube below ambient air temperatures or where condensation control is necessary are to be installed with a vapor

retarder/barrier system of with or without all service vapor retarder sealed jacket (ASJ) system. Without ASJ shall require all longitudinal and circumferential joints to be vapor sealed with vapor barrier mastic.

D. Cellular glass thermal insulation intended for use on surfaces operating at temperatures between −268 and 482 degrees C (−450 and 900 degrees F). It is possible that special fabrication or techniques for pipe insulation, or both, shall be required for application in the temperature range from 121 to 427 degrees C (250 to 800 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 ASJ or PVDC Vapor Retarder jacketing.

B. ASJ shall be white finish (kraft paper) bonded to 0.025 mm (1 mil) thick aluminum foil, fiberglass reinforced, with pressure sensitive adhesive closure. Comply with ASTM C1136. Beach puncture is 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: FSK or PVDC type for concealed ductwork and equipment.

D. Except for flexible elastomeric cellular thermal insulation (not for high humidity exposures), 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 in high humidity locations or 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. Except for cellular glass thermal insulation, when all longitudinal and circumferential joints are vapor sealed with a vapor barrier mastic or caulking, vapor barrier jackets may not be provided. For aesthetic and physical abuse applications, exterior jacketing is recommended. Otherwise field applied vapor barrier jackets shall be provided, in addition to the applicable specified facings and jackets, on all exterior piping as well as on interior piping in high humidity locations or 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.

F. Glass Cloth Jackets: Pre-sized, minimum 0.18 kg per square meter (7.8 ounces per square yard), 2070 kPa (300 psig) bursting strength with integral vapor retarder where required or specified. Weather proof if utilized for outside service.

G. Pipe fitting insulation covering (jackets): Fitting covering shall be pre-molded to match shape of fitting and shall be PVC conforming to Fed Spec L-P-535E, 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. Staples, tacks, or any other attachment that penetrates the PVC covering is not allowed on any form of a vapor barrier system in below ambient process temperature applications.

H. Aluminum Jacket-Piping systems and circular breeching and stacks: 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 or with cut aluminum gores to match shape of fitting and of 0.6 mm (0.024 inch) minimum thickness aluminum. Aluminum fittings shall be of same construction with an internal moisture barrier as straight run jackets but need not be of the same alloy. Factory-fabricated stainless steel bands with wing seals shall be installed on all circumferential joints. Bands shall be 15 mm (0.5 inch) wide on 450 mm (18 inch) centers. System shall be weatherproof if utilized for outside service.

I. Aluminum jacket-Rectangular breeching: ASTM B209, 3003 alloy, H-14 temper, 0.5 mm (0.020 inches) thick with 32 mm (1-1/4 inch) corrugations or 0.8 mm (0.032 inches) thick with no corrugations. System shall be weatherproof if used for outside service.

**2.4 PIPE COVERING PROTECTION SADDLES**

A. Cold pipe support: Pre-molded pipe insulation 180 degrees (half-shells) on bottom half of pipe at supports. Material shall be cellular glass.

| **Nominal Pipe Size and Accessories Material (Insert Blocks)** | |
|---|---|
| **Nominal Pipe Size mm (inches)** | **Insert Blocks mm (inches)** |
| Up through 125 (5) | 150 (6) long |

| Nominal Pipe Size and Accessories Material (Insert Blocks) | |
|---|---|
| **Nominal Pipe Size mm (inches)** | **Insert Blocks mm (inches)** |
| 150 (6) | 150 (6) long |
| 200 (8), 250 (10), 300 (12) | 225 (9) long |
| 350 (14), 400 (16) | 300 (12) long |
| 450 through 600 (18 through 24) | 350 (14) long |

B. Warm or hot pipe supports: Pre-molded pipe insulation (180 degree half-shells) on bottom half of pipe at supports. Material shall be cellular glass. . Insulation at supports shall have same thickness as adjacent insulation. Density of Polyisocyanurate insulation shall be a minimum of 48 kg/$m^3$ (3.0 pcf).

**2.5 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-24179A, Type II Class 1: Adhesive for installing flexible unicellular insulation and for laps and general use.

D. Mil. Spec. MIL-PRF-19565C, Type I: Protective finish for outdoor use.

E. Mil. Spec. MIL-PRFC-19565C, 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. Staples are not allowed for below ambient vapor barrier applications.

C. Wire: 1.3 mm thick (18 gage) soft annealed galvanized or 1.9 mm (14 gage) copper clad steel or nickel copper alloy or stainless steel.

D. Bands: 13 mm (1/2 inch) nominal width, brass, galvanized steel, aluminum or stainless steel.

E. Tacks, rivets, screws or any other attachment device capable of penetrating the vapor retarder shall NOT be used to attach/close the any type of vapor retarder jacketing. Thumb tacks

sometimes used on PVC jacketing and preformed fitting covers closures are not allowed for below ambient vapor barrier applications.

**2.7 REINFORCEMENT AND FINISHES**

A. Glass fabric, open weave: ASTM D1668/D1668M, Type III (resin treated) and Type I (asphalt or white resin treated).

B. Glass fiber fitting tape: Mil. Spec MIL-C-20079H, Type II, Class 1.

C. Hexagonal wire netting: 25 mm (one inch) mesh, 0.85 mm thick (22 gage) galvanized steel.

D. 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.

E. PVC fitting cover: Fed. Spec L-P-535E, Composition A, 11-86 Type II, Grade GU, with Form B Mineral Fiber insert, for media temperature 10 to 121 degrees C (50 to 250 degrees F). Below 10 degrees C (50 degrees F) and above 121 degrees C (250 degrees F) provide mitered pipe insulation of the same type as insulating straight pipe. Provide double layer insert. Provide vapor barrier pressure sensitive tape matching the color of the PVC jacket.

**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 and UL standards and specifications. See paragraph "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 Contracting Officer’s Representative (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 or as noted, 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 with smooth and even surfaces, with jackets and facings drawn tight and smoothly cemented down and sealed at all laps. Insulation shall be continuous through all sleeves and openings, except at fire dampers and duct heaters (NFPA 90A).

D. Vapor retarders shall be continuous and uninterrupted throughout systems with operating temperature 15 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).

E. Install vapor stops with operating temperature 15 degrees C (60 degrees F) and below at all insulation terminations on either side of valves, pumps, fittings, and equipment and particularly in straight lengths every 4.6 to 6.1 meters (approx. 15 to 20 feet) of pipe insulation. The annular space between the pipe and pipe insulation of approx. 25 mm (1 inch) in length at every vapor stop shall be sealed with appropriate vapor barrier sealant. Bio-based materials shall be utilized when possible.

F. Construct insulation on parts of equipment such as cold water pumps and heat exchangers that must be opened periodically for maintenance or repair, so insulation can be removed and replaced without damage. Install insulation with bolted 1 mm thick (20 gage) galvanized steel or aluminum covers as complete units, or in sections, with all necessary supports, and split to coincide with flange/split of the equipment. Do not insulate over equipment nameplate data.

G. 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 coating (caution about coating’s maximum temperature limit) or jacket material.

H. 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.

I. Plumbing work not to be insulated unless otherwise noted:
   1. Piping and valves of fire protection system.
   2. Chromium plated brass piping.
   3. Water piping in contact with earth.
   4. Distilled water piping.

J. Apply insulation materials subject to the manufacturer's recommended temperature limits. Apply adhesives, mastic and coatings at the manufacturer's recommended minimum wet or dry film thickness. Bio-based materials shall be utilized when possible.

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

L. Firestop Pipe insulation:
   1. Provide firestopping insulation at fire and smoke barriers through penetrations. Firestopping insulation shall be UL listed as defined 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
      e. Hourly rated walls

M. Provide vapor barrier systems as follows:
   1. All piping exposed to outdoor weather.
   2. All interior piping conveying fluids below ambient air temperature or in high humidity locations.

N. Provide metal jackets over insulation as follows:
   1. All plumbing piping exposed to outdoor weather.
   2. Piping exposed in building, within 1829 mm (6 feet) of the floor, that connects to sterilizers, kitchen and laundry equipment. Jackets may be applied with pop rivets except for cold pipe or tubing applications. Provide aluminum angle ring escutcheons at wall, ceiling or floor penetrations.
   3. A 50 mm (2 inch) jacket overlap is required at longitudinal and circumferential joints with the overlap at the bottom.

O. Provide PVC jackets over insulation as follows:
   1. Piping exposed in building, within 1829 mm (6 feet) of the floor, on piping that is not precluded in previous sections.
   2. A 50 mm (2 inch) jacket overlap is required at longitudinal and circumferential joints with the overlap at the bottom.

**3.2 INSULATION INSTALLATION**

A. Molded Mineral Fiber Pipe and Tubing Covering:
   1. Fit insulation to pipe, aligning all 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 except for cold piping. Seal all vapor retarder penetrations on cold piping with a generous application of vapor barrier mastic.

Provide cellar glass 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 15 degrees C (60 degrees F) or more.
   b. Factory pre-molded, one piece PVC covers with mineral fiber, (Form B), inserts surface temperature of above 4 degrees C (40 degrees F) to 121 degrees C (250 degrees F). Provide mitered preformed insulation of the same type as the installed straight pipe insulation for pipe temperatures below 4 degrees C (40 degrees F). Secure first layer of mineral fiber insulation with twine. Seal seam edges with vapor barrier mastic and secure with fitting tape.
   c. Factory preformed, ASTM C547 or fabricated mitered sections, joined with adhesive or (hot only) wired in place. (Bio-based materials shall be utilized when possible.) For hot piping finish with a smoothing coat of finishing cement. For cold fittings, 15 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. Cellular Glass Insulation:
   1. Pipe and tubing, covering nominal thickness in millimeters and inches as specified in the schedule at the end of this section.

**3.4 PIPE INSULATION SCHEDULE**

A. Provide insulation for piping systems as scheduled below:

| **Insulation Thickness Millimeters (Inches)** | | | | | |
|---|---|---|---|---|---|
| | | **Nominal Pipe Size Millimeters (Inches)** | | | |
| **Operating Temperature Range/Service** | **Insulation Material** | **Less than 25 (1)** | **25 – 32 (1 – 1¼)** | **38 – 75 (1½ - 3)** | **100 (4) and Greater** |
| 38-60 degrees C (100-140 degrees F)<br>(Domestic Hot Water Supply and Return) | Mineral Fiber (Above ground piping only) | 38 (1.5) | 38 (1.5) | 50 (2.0) | 50 (2.0) |

| | | | | | |
|---|---|---|---|---|---|
| 38-60 degrees C (100-140 degrees F)<br>(Domestic Hot Water Supply and Return) | Cellular Glass<br>Thermal | 38 (1.5) | 38 (1.5) | 50 (2.0) | 50 (2.0) |
| 4-15 degrees C (40-60 degrees F)<br>Domestic Cold Water | Cellular Glass<br>Thermal | 38 (1.5) | 38 (1.5) | 38 (1.5) | 38 (1.5) |

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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.

B. This project will have selected building systems commissioned. The complete list of equipment and systems to be commissioned are 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 REQUIREMENTS. A Commissioning Agent (CxA) appointed by the Department of Veterans Affairs 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 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 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:

**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 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 Resident Engineer. 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 Resident Engineer 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 Resident Engineer 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.

**----- END -----**

**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 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.

D. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

E. Section 07 84 00, FIRESTOPPING.

F. Section 07 92 00, JOINT SEALANTS.

G. Section 09 91 00, PAINTING.

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

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.

**1.3 APPLICABLE PUBLICATIONS**

***Note: From the date contract documents are provided, the Contractor shall use the most current published versions of all listed standards and references below.**

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):

A13.1 .....Scheme for Identification of Piping Systems

B16.3 .....Malleable Iron Threaded Fittings: Classes 150 and 300

B16.9 .....Factory-Made Wrought Buttwelding Fittings

B16.11 .....Forged Fittings, Socket-Welding and Threaded

B16.12 .....Cast Iron Threaded Drainage Fittings

B16.15 .....Cast Copper Alloy Threaded Fittings: Classes 125 and 250

B16.18 .....Cast Copper Alloy Solder Joint Pressure Fittings

B16.22 .....Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings

B16.24 .....Cast Copper Alloy Pipe Flanges and Flanged Fittings: Classes 150, 300, 600, 900, 1500, and 2500

ASME Boiler and Pressure Vessel Code -

BPVC Section IX.....Welding, Brazing, and Fusing Qualifications

C. American Society of Sanitary Engineers (ASSE):

1010 .....Performance Requirements for Water Hammer Arresters

D. American Society for Testing and Materials (ASTM):

A47/A47M.....Standard Specification for Ferritic Malleable Iron Castings

A53/A53M.....Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

A183 .....Standard Specification for Carbon Steel Track Bolts and Nuts

A269/A269M.....Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service

A312/A312M.....Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes

A403/A403M.....Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings

A536 .....Standard Specification for Ductile Iron Castings

A733 .....Standard Specification for Welded and Seamless Carbon Steel and Austenitic Stainless Steel Pipe Nipples

B32 .....Standard Specification for Solder Metal

B43 .....Standard Specification for Seamless Red Brass Pipe, Standard Sizes

B61 .....Standard Specification for Steam or Valve Bronze Castings

B62 .....Standard Specification for Composition Bronze or Ounce Metal Castings

B75/B75M .....Standard Specification for Seamless Copper Tube

B88 .....Standard Specification for Seamless Copper Water Tube

B584 .....Standard Specification for Copper Alloy Sand Castings for General Applications

B687 ..... Standard Specification for Brass, Copper, and Chromium-Plated Pipe Nipples

C919 ..... Standard Practice for Use of Sealants in Acoustical Applications

D1785 ..... Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120

D2564 ..... Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems

D2657 ..... Standard Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings

D2855 ..... Standard Practice for Making Solvent-Cemented Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings

D4101 ..... Standard Specification for Polypropylene Injection and Extrusion Materials

E1120 ..... Standard Specification for Liquid Chlorine

E1229 ..... Standard Specification for Calcium Hypochlorite

F2389 ..... Standard Specification for Pressure-rated Polypropylene (PP) Piping Systems

F2620 ..... Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings

F2769 ..... Standard Specification for Polyethylene of Raised Temperature (PE-RT) Plastic Hot and Cold-Water Tubing and Distribution Systems

E. American Water Works Association (AWWA):

C110 ..... Ductile-Iron and Gray-Iron Fittings

C151 ..... Ductile Iron Pipe, Centrifugally Cast

C153 ..... Ductile-Iron Compact Fittings

C203 ..... Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot Applied

C213 ..... Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines

C651 ..... Disinfecting Water Mains

F. American Welding Society (AWS):

A5.8M/A5.8.....Specification for Filler Metals for Brazing and Braze Welding

G. International Code Council (ICC):

IPC .....International Plumbing Code

H. Manufacturers Specification Society (MSS):

SP-58 .....Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation

SP-72 .....Ball Valves with Flanged or Butt-Welding Ends for General Service

SP-110 .....Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends

I. NSF International (NSF):

14 .....Plastics Piping System Components and Related Materials

61 .....Drinking Water System Components – Health Effects

372 .....Drinking Water System Components – Lead Content

J. Plumbing and Drainage Institute (PDI):

PDI-WH 201.....Water Hammer Arrestors

K. Department of Veterans Affairs:

H-18-8 .....Seismic Design Handbook

H-18-10 .....Plumbing Design Manual

**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 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.

**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.

**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 via electronic file transfer. One operation and maintenance manual 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 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 2023provided 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 certificate if applicable that all results of tests were within limits specified. If a certificate is not available, all documentation shall be on the Certifier's letterhead.

**PART 2 - PRODUCTS**

**2.1 MATERIALS**

A. Material or equipment containing a weighted average of greater than 0.25 percent lead are prohibited in any potable water system intended for human consumption and shall be certified in accordance with NSF 61 or NSF 372. Endpoint devices used to dispense water for drinking shall meet the requirements of NSF 61, Section 9.

B. Plastic pipe, fittings, and solvent cement shall meet NSF 14 and shall be NSF listed for the service intended.

**2.3 ABOVE GROUND (INTERIOR) WATER PIPING**

A. Pipe: Copper tube, ASTM B88, Type K or L, drawn. For pipe6 inches and larger, stainless steel, ASTM A312, schedule40 shall be used.

B. Fittings for Copper Tube:

1. Wrought copper or bronze castings conforming to ASME B16.18 and B16.22. Unions shall be bronze, MSS SP-72, MSS SP-110, solder or braze joints. Use 95/5 tin and antimony for all soldered joints.
2. Grooved fittings,2 to 6 inch wrought copper ASTM B75/B75M C12200,5 to 6 inch bronze casting ASTM B584, C84400. Mechanical grooved couplings,300 psig minimum ductile iron, ASTM A536 Grade 448-310-12 (Grade 65-45-12), or malleable iron, ASTM A47/A47M Grade 22410 (Grade 32510) housing, with EPDM gasket, steel track head bolts, ASTM A183, coated with copper colored alkyd enamel.
3. Mechanical press-connect fittings for copper pipe and tube **are prohibited**. See Plumbing Design Manual for additional information.
4. Mechanically formed tee connection: 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. Braze joints.

5. Flanged fittings, bronze, class 150, solder-joint ends conforming to ASME B16.24.

C. Fittings for Stainless Steel:

1. Stainless steel butt-welded fittings, Type 316, Schedule 10, conforming to ASME B16.9.
2. Grooved fittings, stainless steel, Type 316, Schedule40, conforming to ASTM A403/A403M. Segmentally fabricated fittings are not allowed. Mechanical grooved couplings, ductile iron,600 psig, ASTM A536 Grade 448-310-12 (Grade 65-45-12), or malleable iron, ASTM A47/A47M Grade 22410 (Grade 32510) housing, with EPDM gasket, steel track head bolts, ASTM A183, coated with copper colored alkyd enamel.

D. Adapters: Provide adapters for joining pipe or tubing with dissimilar end connections.

E. Solder: ASTM B32 alloy type Sb5, HA or HB. Provide non-corrosive flux.

F. Brazing alloy: AWS A5.8M/A5.8, brazing filler metals shall be BCuP series for copper-to-copper joints and BAg series for copper to steel joints.

**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: ASTM B43, standard weight.
2. Fittings: ASME B16.15 cast bronze threaded fittings with chrome finish.
3. Nipples: ASTM B687, Chromium-plated.
4. Unions: MSS SP-72, MSS SP-110, brass or bronze with chrome finish. Unions2-1/2 inches and larger shall be flange type with approved gaskets.

B. Unfinished Rooms, Mechanical Rooms: Chrome-plated brass piping is not required. Paint piping systems as specified in Section 09 91 00, PAINTING.

**2.6 TRAP PRIMER WATER PIPING**

A. Pipe: Copper tube, ASTM B88, type K, hard drawn.

B. Fittings: Bronze castings conforming to ASME B16.18 Solder joints.

C. Solder: ASTM B32 alloy type Sb5. Provide non-corrosive flux.

**2.5 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: Less than3 inches, brass or bronze;3 inches and greater, cast iron or semi-steel.

**2.6 DIELECTRIC FITTINGS**

A. Provide dielectric couplings or unions between pipe of dissimilar metals.

**2.7 STERILIZATION CHEMICALS**

A. Hypochlorite: ASTM E1229.

B. Liquid Chlorine: ASTM E1120.

**2.8 WATER HAMMER ARRESTER**

A. Closed copper tube chamber with permanently sealed60 psig 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. Access shall be provided where devices are concealed within partitions or above ceilings. Size and install in accordance with PDI-WH 201 requirements. 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 remove burrs and a clean smooth finish restored to full pipe inside diameter.
3. All pipe runs shall be laid out to avoid interference with other work/trades.

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 IPC, H-18-8 Seismic Design Handbook, MSS SP-58, and SMACNA as required.
    b. Shop Painting and Plating: 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. 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) Pipe Hangers and Riser Clamps: Malleable iron or carbon steel. Pipe Hangers and riser clamps shall have a copper finish when supporting bare copper pipe or tubing.
        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 (minimum) metal protection shield centered on and welded to the hanger and support. The shield thickness and length shall be engineered and sized for distribution of loads to preclude crushing of insulation without breaking the vapor barrier. The shield shall be sized for the insulation and have flared edges to protect vapor-retardant jacket facing. To prevent the shield from sliding out of the clevis hanger during pipe movement, center-ribbed shields shall be used.
        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 6.1 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. Restraint calculations shall be based on the criteria from the manufacturer regarding their restraint design.

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. Firestopping: 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, FIRESTOPPING. Completely fill and seal clearances between raceways and openings with the firestopping materials.
   b. 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.
   c. Acoustical sealant: Where pipes pass through sound rated walls, seal around the pipe penetration with an acoustical sealant that is compliant with ASTM C919.

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 10 working 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 of150 psig 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. Pressure gauge shall have 1 psig increments.

C. All Other Piping Tests: Test new installed piping under 1-1/2 times actual operating conditions and prove tight.

D. The test pressure shall hold for the minimum time duration required by the applicable plumbing code or authority having jurisdiction.

**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.

B. Use liquid chlorine or hypochlorite for sterilization.

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**SECTION 22 11 23**
**DOMESTIC WATER PUMPS**

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

A. Domestic water pressure booster system.

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 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.

D. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

E. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS: Seismic Restraint.

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

G. Section 22 05 12, GENERAL MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT.

H. Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS: Requirements for commissioning, systems readiness checklist, and training.

H. Section 26 29 11, MOTOR CONTROLLERS.

**1.3 APPLICABLE PUBLICATIONS**

***Note: From the date contract documents are provided, the Contractor shall use the most current published versions of all listed standards and references below.**

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):

ASME Boiler and Pressure Code -

BPVC Section VIII-1.....Rules for Construction of Pressure Vessels, Division 1

BPVC Section VIII-2.....Rules for Construction of Pressure Vessels, Division 2-Alternative Rules

C. American Society for Testing and Materials (ASTM):

A48/A48M.....Standard Specification for Gray Iron Castings

B584 .....Standard Specification for Copper Alloy Sand Castings for General Applications

D. International Code Council (ICC)

IPC .....International Plumbing Code

E. National Electrical Manufacturers Association (NEMA):

ICS 6.....Industrial Control and Systems: Enclosures

250 .....Enclosures for Electrical Equipment (1000 Volts Maximum)

F. NSF International (NSF)

61 .....Drinking Water System Components – Health Effects

372 .....Drinking Water System Components – Lead Content

G. Underwriters' Laboratories, Inc. (UL):

508 .....Standards for Industrial Control Equipment

778 .....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.
2. Motor:
    a. Manufacturer
    b. Speed.
    c. Current Characteristics.
    d. Efficiency.

3. Tank:
    a. Manufacturer and model.
    b. Capacity
4. Drive: Information in accordance with Section 26 29 11, MOTOR CONTROLLERS.

D. Certificate of shop test for domestic water booster system. Provide certified performance curves.

E. Certified copies of all the factory and construction site test data sheets and reports.

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. 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. 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.

C. Domestic Water Pressure Booster System:

1. Components shall be furnished by a single manufacturer and the system shall be the standard cataloged product of the manufacturer.

2. Shop Test: Water booster unit and its component parts shall undergo a thorough electric and hydraulic operating test prior to shipment. Tests shall include a system operating flow test from zero to 100 percent of design flow rate under specified suction and system pressure conditions. Certified performance curves shall be furnished.

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.

**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 as well as a physical copy 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. As-built drawings are to be provided, and a copy of them in Auto-CAD version 2015 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 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.

**2.4 DOMESTIC WATER PRESSURE BOOSTER SYSTEM**

A. General: Provide a factory prefabricated, prewired and pretested multi-stage pumping system including variable speed drive motors, pressure regulating valves with integral check valves, pressure transducers, vibration pads, emergency switches, duplex flow switches, power and control panels, suction and discharge manifolds, butterfly isolation valves, ball drain valves, bypass loops with appropriate valves and check valves, low pressure cut-off switches, hydropneumatic tanks and accessories. All components shall be furnished by a single manufacturer and the system shall be the standard cataloged product of the manufacturer. All components shall be factory installed on a common structural steel skid and shall be completely tested in the factory before shipment. Manufacturer shall assume "unit responsibility" to ensure that all components effectively interface to execute the operation of the designed system.

B. System Operation and Configuration:

1. System shall automatically maintain constant system pressures scheduled on drawings of 65 psig at the outlet of the pressure control valve and hydro-pneumatic tank check valve at all times. Suction pressure varies from 40 psig) to 25 psig).

2. Duplex pump systems shall include both pumps sized for75 percent of the total capacity.

C. Centrifugal Pump: Pumps shall be single stage, in-line pump with variable speed drive motor, low pressure cut-off switches and bypass loops with ball, gate, and check valves as indicated on the Contract Drawings.
   1. Impellers: ASTM B584 Cast bronze, radially or vertically split keyed to shaft and secured by a locking cap-screw. Each impeller shall be statically and dynamically balanced prior to assembly in pump casing. Provide replaceable bronze casing wear rings.
   2. Pump shaft: Steel, with replaceable bronze shaft sleeve completely covering the wetted area of the shaft under the seal.
   3. Lubrication: Water lubricated type pump.
   4. Pump Casing: ASTM A48/A48M CL20 Cast iron suitable for 1200 kPa (175 psig). Pump volute shall be supplied with vent and drain tappings. Connections shall be female NPT. The casing shall be O-ring sealed to the seal housing.
   5. Seal: Mechanical general purpose type, with sleeve mounting. Seal shall be rated at 1200 kPa (175 psig) maximum.
   6. Adjustable Spacer Coupling: Removable type required so that pump seal can be replaced without disturbing motor.
   7. Motor: Solid shaft motors balanced to 0.22 mm (0.0085 inch) vibration amplitude shall be operated at any point on the pump head curve without overloading the motor. Conform to NEMA Type 2.

D. Vertical Multistage Pump: Pumps shall be vertical multistage short-coupled pumps with variable speed drive motor, low pressure cut-off switches and bypass loops with ball, butterfly, check valves as indicated on the Contract Drawings.
   1. Impellers: Cast bronze, mixed flow enclosed type.
   2. Balancing of Impellers: Each impeller shall be statically and dynamically balanced prior to assembly in pump casing.
   3. Pump shaft: Stainless steel Type 416.
   4. Lubrication: Water lubricated type pump.
   5. Pump Bowls: Cast Iron, stainless steel or bronze flanged and bolted.
   6. Pump Bearings: Bronze, radial type.

7. Pump Head: Fabricated steel with continuous bypass for low seal pressure. Cast iron heads are prohibited. Pump head shall be lined same as pump barrel.
8. Seal: Mechanical general purpose type, with sleeve mounting. Seal shall be rated at 1200 kPa (175 psig) maximum.
9. Adjustable Spacer Coupling: Removable type required so that pump seal can be replaced without disturbing motor.
10. Motor: Solid shaft motors balanced to 0.22 mm (0.0085 inch) vibration amplitude shall be operated at any point on the pump head curve without overloading the motor. Conform to NEMA Type 2.
11. Pump Barrel: Schedule 40 steel pipe with two-coat "baked" internal lining to meet the potable water requirements of U.S. Food and Drug Administration. Bio-based materials shall be utilized when possible. Unlined pump barrels are prohibited. Provide drain tapping.

E. Pressure Regulating Valves: System pressure shall be maintained by pilot-operated, diaphragm type pressure regulating valves, rated at 2070 kPa (300 psig) minimum, one for each pump. Valves shall be piloted to control system pressure and to cause the valve to act as a non-slam check valve. Pilot shall be rated at 1200 kPa (175 psig) minimum.

F. Hydro-pneumatic Tank: Bladder type, hydro-pneumatic, designed and constructed in accordance with requirements of the ASME Pressure Vessel Code and stamped with appropriate symbol. Tank shall include pre-pressurized, sealed-in air cushion which shall accommodate pressure increases and expanded water volumes in the tank. Tank shall include butyl rubber or poly-propylene liner in lower, or water side of chamber. Minimum working pressure of tank shall be 1200 kPa (175 psig). Unit shall be designed and manufactured for domestic water applications. Insulate tank as specified. Check valve at hydro-pneumatic tank shall include small orifice for undue loading.

G. Power and Control Panel: Class "A" shadow box double NEMA 1 enclosure, UL labeled, bonderized double prime coated with baked enamel finish:
1. Fused disconnect switches with external operating handles.
2. Magnetic contactor for each motor with HOA switch.
3. Door interlock.
4. Thermal overload protection relay for each motor, three leg type.
5. Running light for each motor.

6. Power light for each motor.
7. Control transformer, switch, circuit breaker, light.
8. Lead pump failure protection.

H. Motor and Starter: Maximum 40 degrees C (104 degrees F) ambient temperature rise, drip-proof type motor, ball bearings, voltage and phase as shown in schedule on Electrical drawings, conforming to NEMA Type 4. Motor shall be of such capacity that brake horsepower required by driven equipment at normal rated capacity will not exceed nameplate rating of the motor. Refer to Section 22 05 12, GENERAL MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT. Provide each motor with automatic, fully enclosed, magnetic starter of type specified in Section 26 29 11, MOTOR CONTROLLERS.

I. Instrumentation: All instrumentation shall be factory installed and shall include the following 115 mm (4-1/2 inch) dial gages with shut-off cock.
   1. Pump pressure gage for each pump.
   2. System pressure gage.
   3. Suction pressure gage.

J. Operating and Emergency Controls:
   1. The pump station shall receive a 4-20mA signal from each pressure transducer, as provided by the pumping station manufacturer. A pressure transducer signal shall be provided for each pump controller. The differential pressure transducers shall monitor system discharge pressure versus suction line pressure and provide an analog signal 4-20mA to the pump control software, and allow the variable speed pump controller, to provide a variable Volts/Hz output to the motor. Once the pressure drops below the set system pressure, the pump shall start and provide system pressure (as determined by the station operator or program), if this pressure cannot be maintained by one pump, the next pump in sequence shall operate in a lead/lag capacity to provide the extra flow and pressure automatically without the use of additional panels or alternators. The sequence of the pumps shall be field adjustable, and completely automatic without additional panels or alternator controls. The variable speed pump controller shall be completely integrated with the VFD. Special type motors shall not be allowed. Refer to Section 22 05 12, GENERAL MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT. Pump assignments shall alternate as described below. All program settings shall be based on centrifugal pump language and centrifugal pumps.

Program settings shall be field adjustable to provide onsite adjustments. When the system experiences low demand, the variable speed pump controllers shall reduce the speed of each pump, until demand has stopped. Pump controllers shall stop each pump at zero demand, without the use of external switches or controls.

2. The pumping system includes multiple pumps as indicated above. In two-pump systems, the first (lead) pump operates initially, and the second pump serves as a lag pump capable of operating concurrently with the lead pump to add capacity when needed. The second pump also acts as a stand-by pump at lower demands, ready for operation if the lead pump is taken out of service. Pump assignments shall alternate to automatically equalize the run time in similarly sized pumps, which excludes uniquely-sized lead pumps.
3. The pump logic controller shall provide the following standard user-selectable features:
    a. Low Suction Pressure Alarm and Cut Out
    b. High Suction Pressure Alarm and Cut Out
    c. Low System Pressure Alarm
    d. High System Pressure Alarm and Cut Out
    e. High Temperature Alarm and Cut Out
    f. Low Level Alarm and Cut Out
    g. No-Flow Shut Down
    h. Audible/Visible alarm with push to silence feature
    i. Overload Failure Alarm
    j. Pump Failure Alarm
    k. Pump operating order assignments
    l. Minimum run timers to prevent short cycle operation.
4. Provide auxiliary contacts for remote communication with the BAS, including the following input/output points:
    a. Domestic water supply pressure (analog input to BAS)
    b. Alarm condition activated (binary input to BAS)
    c. Run status of lead pump (binary input to BAS)
    d. Run status of lag pump (binary input to BAS)
    e. Run status of stand-by pump (binary input to BAS)

K. Factory Test: The booster system and its component parts shall undergo a complete operation flow test from zero to 100 percent design flow rate under the specified suction and net system pressure conditions. The system certification shall include copies of the test and test data as performed in the factory prior to shipment. Performance test certifications should be placed inside the system control panel and two extra copies shall be provided to the COR with the installation manual.

**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 10 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 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.

B. A complete listing of common 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 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.

D. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

E. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS: Seismic Restraint.

F. Section 07 84 00, FIRESTOPPING: Penetrations in rated enclosures.

G. Section 07 92 00, JOINT SEALANTS: Sealant products.

H. Section 09 91 00, PAINTING: Preparation and finish painting and identification of piping systems.

I. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING: Pipe Hangers and Supports, Materials Identification.

J. Section 22 07 11, PLUMBING INSULATION.

K. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

**1.3 SECTION 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMSAPPLICABLE PUBLICATIONS**

***Note: From the date contract documents are provided, the Contractor shall use the most current published versions of all listed standards and references below.**

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):

A13.1 .....Identification of Piping Systems

A112.36.2M.....Cleanouts

A112.6.3 .....Floor and Trench Drains

B1.20.1 ..... Pipe Threads, General Purpose (Inch)

B16.1 ..... Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250

B16.4 ..... Grey Iron Threaded Fittings Classes 125 and 250

B16.15 ..... Cast Copper Alloy Threaded Fittings, Classes 125 and 250

B16.18 ..... Cast Copper Alloy Solder Joint Pressure Fittings

B16.21 ..... Nonmetallic Flat Gaskets for Pipe Flanges

B16.22 ..... Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings

B16.23 ..... Cast Copper Alloy Solder Joint Drainage Fittings: DWV

B16.24 ..... Cast Copper Alloy Pipe Flanges and Flanged Fittings, and Valves: Classes 150, 300, 600, 900, 1500, and 2500

B16.29 ..... Wrought Copper and Wrought Copper Alloy Solder-Joint Drainage Fittings: DWV

B16.39 ..... Malleable Iron Threaded Pipe Unions Classes 150, 250, and 300

B18.2.1 ..... 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):

1001 ..... Performance Requirements for Atmospheric Type Vacuum Breakers

1018 ..... Performance Requirements for Trap Seal Primer Valves – Potable Water Supplied

1044 ..... Performance Requirements for Trap Seal Primer Devices – Drainage Types and Electronic Design Types

1079 ..... Performance Requirements for Dielectric Pipe Unions

D. American Society for Testing and Materials (ASTM):

A53/A53M ..... Standard Specification for Pipe, Steel, Black And Hot-Dipped, Zinc-coated, Welded and Seamless

A74 ..... Standard Specification for Cast Iron Soil Pipe and Fittings

A888 ..... Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications

B32 ..... Standard Specification for Solder Metal

B43 .....Standard Specification for Seamless Red Brass Pipe, Standard Sizes

B88 .....Standard Specification for Seamless Copper Water Tube

B306 .....Standard Specification for Copper Drainage Tube (DWV)

B687 .....Standard Specification for Brass, Copper, and Chromium-Plated Pipe Nipples

B813 .....Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube

B828 .....Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings

C564 .....Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings

E. Cast Iron Soil Pipe Institute (CISPI):

.....Cast Iron Soil Pipe and Fittings Handbook

301 .....Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications

310 .....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):

A4015-14/19 .....Copper Tube Handbook

G. International Code Council (ICC):

IPC .....International Plumbing Code

H. Manufacturers Standardization Society (MSS):

SP-123 .....Non-Ferrous Threaded and Solder-Joint Unions for Use with Copper Water Tube

I. National Fire Protection Association (NFPA):

70 .....National Electrical Code (NEC)

J. Underwriters' Laboratories, Inc. (UL):

508-99 .....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 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.

**1.5 QUALITY ASSURANCE**

A. 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.

B. Refer to Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS for additional sustainable design requirements.

**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 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. 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 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.
4. Cast iron pipe and fittings shall be made from a minimum of 95 percent post-consumer recycled material.
5. 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.

B. Copper Tube, (DWV):

1. Copper DWV tube sanitary waste, drain and vent pipe may be used for piping above ground, except for urinal drains.
2. The copper DWV tube shall be drainage type, drawn temper conforming to ASTM B306.
3. The copper drainage fittings shall be cast copper or wrought copper conforming to ASME B16.23 or ASME B16.29.
4. The joints shall be lead free, using a water flushable flux, and conforming to ASTM B32.

**2.2 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. 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 in the

contract document and at every building exit. 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.

**2.3 FLOOR DRAINS**

A. General Data: floor drain shall comply with ASME A112.6.3. A caulking flange, inside gasket, or hubless connection shall be provided for connection to cast iron pipe, screwed or no hub outlets for connection to steel pipe. The drain connection shall be bottom outlet. A membrane clamp and extensions shall be provided, if required, where installed in connection with waterproof membrane. Puncturing membrane other than for drain opening shall not be permitted. Double drainage pattern floor drains shall have integral seepage pan for embedding into floor construction, and weep holes to provide adequate drainage from pan to drain pipe. For drains not installed in connection with a waterproof membrane, a.45 kg (16-ounce) soft copperflashing membrane, 600 mm (24 inches) square or another approved waterproof membrane shall be provided.

B. Type M (FD-M) medium duty (non-traffic) floor drain shall comply with ASME A112.6.3. The type M floor drain shall have a cast iron body, nickel bronze adjustable funnel strainer and clamping device. Funnel strainer shall consist of a perforated floor-level square or round grate and funnel extension for indirect waste. Cut-out grate below funnel. Minimum dimensions as follows:

1. Area of strainer and collar – 23,000 square mm (36 square inches).
2. Height of funnel – 95 mm (3-3/4 inches).
3. Diameter of lower portion of funnel – 50 mm (2 inches).
4. Diameter of top portion of funnel – 100 mm (4 inches).

5. Provide paper collars for construction purposes.

**2.4 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 the piping they are connected to. Slip joints are prohibited 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.

**2.5 PRIMER VALVES AND TRAP SEAL PRIMER SYSTEMS**

A. Trap Primer (TP-2): The trap seal primer valve shall be hydraulic, supply type with a pressure rating of 861 kPa (125 psig) and conforming to standard ASSE 1018.
   1. The inlet and outlet connections shall be 15 mm or DN15 (NPS 1/2 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.

**2.6 PENETRATION SLEEVES**

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 shall extend 50 mm (2 inches) above finished floor and galvanized steel pipe extension in the bottom of the fitting that shall 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 greater 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. 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"

K. Aboveground copper tubing shall be installed according to Copper Development Association's (CDA) "Copper Tube Handbook".

L. 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 JOINT CONSTRUCTION**

A. Hub and spigot, cast iron piping with gasket joints shall be joined in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.

B. Hub and spigot, cast iron piping with calked joints shall be joined in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead and oakum calked joints.

C. 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.

D. 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.

E. Copper tube and fittings with soldered joints shall be joined according to ASTM B828. A water flushable, lead free flux conforming to ASTM B813 and a lead-free alloy solder conforming to ASTM B32 shall be used.

**3.3 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, COMMON WORK RESULTS FOR PLUMBING 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 painted according to Section 09 91 00, PAINTING. 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. 75 mm or DN75 (NPS 3 inch): 1500 mm (60 inches) with 15 mm (1/2 inch) rod.
3. 100 mm or DN100 to 125 mm or DN125 (NPS 4 inch to NPS 5 inch): 1500 mm (60 inches) with 18 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 20 mm (3/4 inch) rod.
5. 250 mm or DN250 to 300 mm or DN300 (NPS 10 inch to NPS 12 inch): 1500 mm (60 inch) with 23 mm (7/8 inch) rod.

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, 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.

G. Miscellaneous materials shall be provided as specified, required, directed or as noted in the contract documents 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 provided 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 shall be completely sealed around the pipe and make watertight with sealant as specified in Section 07 92 00, JOINT SEALANTS.

J. Exhaust vents shall be extended separately through roof. Sanitary vents shall not connect to exhaust vents.

**3.4 TESTS**

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

B. Waste System 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 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.

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**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 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.

D. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

E. Section 07 84 00, FIRESTOPPING: Penetrations in rated enclosures.

F. Section 07 92 00, JOINT SEALANTS.

G. Section 09 91 00, PAINTING: Preparation and finish painting and identification of piping systems.

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

I. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING: Pipe Hangers and Supports, Materials Identification.

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

K. Section 22 07 11, PLUMBING INSULATION.

**1.3 APPLICABLE PUBLICATIONS**

***Note: From the date contract documents are provided, the Contractor shall use the most current published versions of all listed standards and references below.**

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):

A112.6.4- .....Roof, Deck, and Balcony Drains

A13.1-.....Scheme for Identification of Piping Systems

B1.20.1 .....Pipe Threads, General Purpose, Inch

B16.3 .....Malleable Iron Threaded Fittings: Classes 150 and 300

B16.9 .....Factory-Made Wrought Buttwelding Fittings

B16.11 .....Forged Fittings, Socket-Welding and Threaded

B16.12 .....Cast Iron Threaded Drainage Fittings

B16.15 .....Cast Copper Alloy Threaded Fittings: Classes 125 and 250

B16.18 .....Cast Copper Alloy Solder-Joint Pressure Fittings

B16.22 .....Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings

B16.23 .....Cast Copper Alloy Solder Joint Drainage Fittings - DWV

B16.29 .....Wrought Copper and Wrought Copper Alloy Solder-Joint Drainage Fittings – DWV

C. American Society of Sanitary Engineering (ASSE)

1079 .....Performance Requirements for Dielectric Pipe Unions

D. American Society for Testing and Materials (ASTM):

A47/A47M.....Standard Specification for Ferritic Malleable Iron Castings

A53/A53M.....Standard Specification for Pipe, Steel, Black And Hot-Dipped, Zinc-coated Welded and Seamless

A74 .....Standard Specification for Cast Iron Soil Pipe and Fittings

A183 .....Standard Specification for Carbon Steel Track Bolts and Nuts

A312/A312M.....Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes

A536 .....Standard Specification for Ductile Iron Castings

A733 .....Standard Specification for Welded and Seamless Carbon Steel and Austenitic Stainless Steel Pipe Nipples

A888 .....Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications

B32 .....Standard Specification for Solder Metal

B61 .....Standard Specification for Steam or Valve Bronze Castings

B62 .....Standard Specification for Composition Bronze or Ounce Metal Castings

B75/B75M .....Standard Specification for Seamless Copper Tube

B88 .....Standard Specification for Seamless Copper Water Tube

B306 .....Standard Specification for Copper Drainage Tube (DWV)

B584 ..... Standard Specification for Copper Alloy Sand Castings for General Applications

B687 ..... Standard Specification for Brass, Copper, and Chromium-Plated Pipe Nipples

B828 ..... Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings

B813 ..... Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube

C564 ..... Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings

C1173 ..... Standard Specification for Flexible Transition Couplings for Underground Piping Systems

D1785 ..... Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80 and 120

D2000 ..... Standard Classification System for Rubber Products in Automotive Applications

D2321 ..... Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications

D2564 ..... Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems

D2665 ..... Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings

D2855 ..... Standard Practice for Making Solvent-Cemented Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings

D4101 ..... Standard Specification for Polypropylene Injection and Extrusion Materials

D5926 ..... Standard for Poly (Vinyl Chloride) (PVC) Gaskets for Drain, Waste, and Vent (DWV), Sewer, Sanitary, and Storm Plumbing Systems

F477 ..... Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe

F656 .....Standard Specification for Primers for Use in Solvent Cement Joints of Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings

F1545 .....Standard Specification for Plastic-Lined Ferrous Metal Pipe, Fittings, and Flanges

E. American Welding Society (AWS):

A5.8M/A5.8 AMD1.....Specification for Filler Metals for Brazing and Braze Welding

F. Copper Development Association (CDA):

A4015 .....Copper Tube Handbook

G. Cast Iron Soil Pipe Institute (CISPI):

301 .....Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications

310 .....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

H. International Code Council (ICC):

IPC .....International Plumbing Code

I. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS):

SP-72 .....Ball Valves with Flanged or Butt-Welding Ends for General Service

SP-110 .....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. Downspout Nozzles.
7. Sleeve Flashing Devices.

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

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.

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

B. 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 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. Pipe buried in or in contact with earth.
   b. Extension of pipe to a distance of approximately 1500 mm (5 feet) outside of building walls.
   c. Interior storm piping above grade.

2. The cast iron storm pipe shall be bell and spigot, or hubless (plain end or no-hub) as required by selected jointing method.
3. 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.
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 C564.

B. Copper Tube, (DWV): May be used for piping above ground.
1. The copper DWV tube shall be drainage type, drawn temper conforming to ASTM B306.
2. The copper drainage fittings shall be cast copper or wrought copper conforming to ASME B16.23 or ASME 16.29.
3. The joints shall be lead free, using a water flushable flux, and conforming to ASTM B32.

**2.4 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.

**2.5 ROOF DRAINS AND CONNECTIONS**

A. Roof Drains: Roof Drains (RD) 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. Canopy Roofs: The roof drain shall have a beehive or dome shaped strainer with the integral flange no greater than 200 mm (8 inches) in diameter. For an insulated roof, the roof drain shall be provided with an adjustable drainage collar, which can be raised or lowered to meet the required insulation heights, sump receiver and deck clamp. Bottom section shall serve as roof drain during construction before insulation is installed.
3. Promenade Decks: the roof drain shall be the same as for canopy roofs, except decks shall have flat, round, loose, non-slip, bronze grate set in square, non-slip, bronze frame.
4. Portico Roofs and Gutters: Roof drains shall be horizontal angle type drain with flat bottom and horizontal outlet at the same elevation as the pipe to which it is connected. Strainer shall be removable angle grate type.
5. 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.

6. 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.
7. 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. Interior Downspouts: An expansion joint shall be provided, specified above, at top of run on straight, vertical runs of downspout piping 12 m (40 feet) long or greater.
D. Downspout Nozzle: The downspout nozzle fitting shall be of brass, unfinished, with internal pipe thread for connection to downspout.

**2.6 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. Hub and spigot, cast iron piping with gasket joints shall be joined in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.

B. Hub and spigot, cast iron piping with calked joints shall be joined in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead and oakum calked joints.

C. Hubless, cast iron piping shall be joined in accordance with CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless piping coupling joints.

D. 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.

E. Copper tube and fittings with soldered joints shall be joined according to ASTM B828. A water flushable, lead free flux conforming to ASTM B813 and a lead free alloy solder conforming to ASTM B32 shall be used.

F. 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 appendices.

**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.

E. The maximum support spacing for horizontal plastic 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 4.6 m (15 feet).

G. 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.

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 6.1 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.

I. Cast escutcheon with set screw shall be installed 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 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 horizontal sections and 600 mm (2 feet) past changes of direction to vertical sections for interior section of roof drains. 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.

C. COR shall witness all tests. Contractor shall coordinate schedules with the COR. Contractor shall provide a minimum of 10 working days prior to flushing, disinfection/sterilization, startup, and testing.

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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, HEATING, VENTILATING, AND AIR CONDITIONING (HVAC).

B. Definitions:

1. Exposed: Piping, ductwork, and equipment exposed to view in finished rooms.
2. Exterior: Piping, ductwork, and equipment exposed to weather be it temperature, humidity, precipitation, wind, or solar radiation.

C. Abbreviations/Acronyms:

1. ac: Alternating Current
2. AC: Air Conditioning
3. ACU: Air Conditioning Unit
4. ACR: Air Conditioning and Refrigeration
5. AI: Analog Input
6. AISI: American Iron and Steel Institute
7. AO: Analog Output
8. ASJ: All Service Jacket
9. AWG: American Wire Gauge
10. BACnet: Building Automation and Control Networking Protocol
11. BAS: Building Automation System
12. bhp: Brake Horsepower
13. Btu: British Thermal Unit
14. Btu/h: British Thermal Unit Per Hour
15. CDA: Copper Development Association
16. C: Celsius
17. CD: Compact Disk
18. CFM: Cubic Foot Per Minute
19. CH: Chilled Water Supply
20. CHR: Chilled Water Return
21. COR: Contracting Officer’s Representative

22. CPD: Condensate Pump Discharge
23. CPVC: Chlorinated Polyvinyl Chloride
24. CRS: Corrosion Resistant Steel
25. CW: Cold Water
26. CxA: Commissioning Agent
27. DDC: Direct Digital Control
28. DI: Digital Input
29. DO: Digital Output
30. DVD: Digital Video Disc
31. DN: Diameter Nominal
32. DWV: Drainage, Waste and Vent
33. EPDM: Ethylene Propylene Diene Monomer
34. EPT: Ethylene Propylene Terpolymer
35. ETO: Ethylene Oxide
36. F: Fahrenheit
37. FAR: Federal Acquisition Regulations
38. FD: Floor Drain
39. FED: Federal
40. HDPE: High Density Polyethylene
41. hp: Horsepower
42. HW: Hot Water
43. HWH: Hot Water Heating Supply
44. HWHR: Hot Water Heating Return
45. Hz: Hertz
46. ID: Inside Diameter
47. IPS: Iron Pipe Size
48. kg: Kilogram
49. klb: 1000 lb
50. kPa: Kilopascal
51. lb: Pound
52. lb/hr: Pounds Per Hour
53. L/s: Liters Per Second

54. L/min: Liters Per Minute
55. MAX: Maximum
56. MBtu/h: 1000 Btu/h
57. MBtu: 1000 Btu
58. m: Meter
59. MFG: Manufacturer
60. mg: Milligram
61. mg/L: Milligrams Per Liter
62. MIN: Minimum
63. ml: Milliliter
64. mm: Millimeter
65. NC: Normally Closed
66. NO: Normally Open
67. NPT: National Pipe Thread
68. NPS: Nominal Pipe Size
69. OD: Outside Diameter
70. OSD: Open Sight Drain
71. PLC: Programmable Logic Controllers
72. PP: Polypropylene
73. PPE: Personal Protection Equipment
74. ppb: Parts Per Billion
75. ppm: Parts Per Million
76. PRV: Pressure Reducing Valve \
77. psig: Pounds Per Square Inch Gauge
78. PTFE: Polytetrafluoroethylene
79. PVC: Polyvinyl Chloride
80. PVDC: Polyvinylidene Chloride Vapor Retarder Jacketing, White
81. PVDF: Polyvinylidene Fluoride
82. RH: Relative Humidity
83. RPM: Revolutions Per Minute
84. SCFM: Standard Cubic Feet Per Minute
85. SPEC: Specification

86. STD: Standard
87. TAB: Testing, Adjusting, and Balancing
88. TEFC: Totally Enclosed Fan-Cooled
89. THERM: 100,000 Btu
90. THHN: Thermoplastic High-Heat Resistant Nylon Coated Wire
91. THWN: Thermoplastic Heat & Water-Resistant Nylon Coated Wire
92. T/P: Temperature and Pressure
93. V: Volt
94. VAC: Vacuum
95. VA: Veterans Administration
96. VAC: Voltage in Alternating Current
97. VA CFM: VA Construction & Facilities Management
98. VA CFM CSS: VA Construction & Facilities Management, Consulting Support Service
99. VAMC: Veterans Administration Medical Center
100. VHA OCAMES: Veterans Health Administration – Office of Capital Asset Management Engineering and Support

**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 74 19, CONSTRUCTION WASTE MANAGEMENT.
D. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.
E. Section 02 82 11, TRADITIONAL ASBESTOS ABATEMENT.
F. Section 03 30 00, CAST-IN-PLACE CONCRETE.
G. Section 05 31 00, STEEL DECKING.
H. Section 05 36 00, COMPOSITE METAL DECKING.
I. Section 05 50 00, METAL FABRICATIONS.
J. Section 07 84 00, FIRESTOPPING.
K. Section 07 92 00, JOINT SEALANTS.
L. Section 09 91 00, PAINTING.
M. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.
N. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION EQUIPMENT.

O. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.

P. Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.

Q. Section 23 07 11, HVAC AND BOILER PLANT INSULATION.

R. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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

T. Section 23 36 00, AIR TERMINAL UNITS.

U. Section 23 82 00, CONVECTION HEATING AND COOLING UNITS.

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

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

X. Section 26 29 11, MOTOR CONTROLLERS.

**1.3 APPLICABLE PUBLICATIONS**

***Note: From the date contract documents are provided, the Contractor shall use the most current published versions of all listed standards and references below.**

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-Conditioning, Heating, and Refrigeration Institute (AHRI):

430 .....Performance Rating of Central Station Air-Handling Unit Supply Fans

C. Air Movement and Control Association (AMCA):

410 .....Recommended Safety Practices for Users and Installers of Industrial and Commercial Fans

D. American Society of Mechanical Engineers (ASME):

B31.1 .....Power Piping

B31.9 .....Building Services Piping

ASME Boiler and Pressure Vessel Code:

BPVC Section IXWelding, Brazing, and Fusing Qualifications

E. American Society for Testing and Materials (ASTM):

A36/A36M.....Standard Specification for Carbon Structural Steel

A575 .....Standard Specification for Steel Bars, Carbon, Merchant Quality, M-Grades

F. Association for Rubber Products Manufacturers (ARPM):

IP-20 .....Specifications for Drives Using Classical V-Belts and Sheaves

IP-21 .....Specifications for Drives Using Double-V (Hexagonal) Belts

IP-24 .....Specifications for Drives Using Synchronous Belts

IP-27 .....Specifications for Drives Using Curvilinear Toothed Synchronous Belts

G. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc.(MSS):

SP-58 .....Pipe Hangers and Supports-Materials, Design, Manufacture, Selection, Application, and Installation

SP-127 .....Bracing for Piping Systems: Seismic–Wind–Dynamic Design, Selection, and Application

H. Military Specifications (MIL):

MIL-P-21035B.....Paint High Zinc Dust Content, Galvanizing Repair (Metric)

I. National Fire Protection Association (NFPA):

70 .....National Electrical Code (NEC)

101 .....Life Safety Code

J. Department of Veterans Affairs (VA):

PG-18-10 .....Physical Security and Resiliency Design Manual

**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 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 accessable 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. Hangers, inserts, supports, and bracing.

c. Pipe sleeves.

d. Duct or equipment penetrations of floors, walls, ceilings, or roofs.

H. 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. 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, paragraph 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 for belts: Belt manufacturer, model number, size and style, and distinguished whether of multiple belt sets.

K. Provide copies of approved HVAC equipment submittals to the and Commissioning Subcontractor.

L. 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 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.

**1.5 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 onsite, 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 sections 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, chillers, cooling towers, control systems, pumps, critical instrumentation, computer workstation 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. HVAC mechanical systems welding shall meet 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 paragraph 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. Guaranty: Warranty of Construction, FAR Clause 52.246-21.

K. 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 specification section. For more information regarding the product categories covered by the Bio-Preferred Program, visit http://www.biopreferred.gov.

L. Refer to Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS for additional sustainable design requirements.

**1.6 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 boilers, chillers, cooling towers, 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. Boilers shall be left clean following final internal inspection by Government, insurance representative, or inspector.
   5. Contractor shall be fully responsible for all costs, damage, and delay arising from failure to provide clean systems.

**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, 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. Red-lined, hand-marked drawings are to be provided, with one paper copy and a scanned PDF version of the hand-marked drawings provided on CD or DVD.

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.

**1.8 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 VAMC.

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

C. Steam and Condensate Service Interruptions: Limited steam and condensate 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 VAMC. These non-critical periods are limited to between 8 pm and 5 am in the appropriate off-season (if applicable). Provide at least 10 working days advance notice to the COR. The request shall include a detailed plan on the proposed shutdown and the intended work to be done along with manpower levels. All equipment and materials shall be onsite and verified with plan 5days prior to the shutdown or it will need to be rescheduled.

D. Phasing of Work: Comply with all requirements shown on contract documents. Contractor shall submit a complete detailed 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.

E. 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.

F. 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 FACTORY ASSEMBLED PRODUCTS**

A. Provide maximum standardization of components to reduce spare part requirements.

B. Performance and warranty of all components that make up an assembled unit shall be the responsibility of the manufacturer of the completed assembly.

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. Equipment and components of equipment shall bear manufacturer's name and trademark, model number, serial number and performance data on a nameplate 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. Exceptions must be approved by the VA, but may be permitted if performance requirements cannot be met.

**2.2 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 plant that conforms to contract requirements.

**2.3 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.

**2.4 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 EQUIPMENT; Section 26 29 11, MOTOR CONTROLLERS; 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.

**2.5 EQUIPMENT AND MATERIALS IDENTIFICATION**

A. Use symbols, nomenclature and equipment numbers specified, shown in the contract documents, and shown in the maintenance manuals. Identification for piping is specified in Section 09 91 00, PAINTING.

B. 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. Identify unit components such as coils, filters, fans, etc.

C. 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.

D. 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.

E. Valve Tags and Lists:

1. HVAC and Mechanical Rooms: Provide for all valves other than for equipment in Section 23 82 00, CONVECTION HEATING AND COOLING UNITS and Section 23 36 00, AIR TERMNAL UNITS.
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 mm (1/4 inch) for service designation on 19-gauge 38 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 216 mm (8-1/2 inches) by 279 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.

**2.6 FIRESTOPPING**

A. Section 07 84 00, FIRESTOPPING specifies an effective barrier against the spread of fire, smoke and gases where penetrations occur for piping and ductwork. Refer to Section 23 07 11, HVAC AND BOILER PLANT INSULATION, for firestop pipe and duct insulation.

**2.7 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 279 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 shall be used for individual copper tubing up to 22 mm (7/8 inch) outside diameter.

F. Attachment to Metal Pan or Deck: As required for materials specified in Section 05 31 00, STEEL DECKING or Section 05 36 00, COMPOSITE METAL DECKING.

G. Attachment to Existing Structure: Support from existing floor/roof frame.

H. Attachment to Wood Construction: Wood screws or lag bolts.

I. 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 38 mm (1-1/2 inches) minimum of adjustment and incorporate locknuts. All-thread rods are acceptable.

J. Hangers Supporting Multiple Pipes (Trapeze Hangers): Galvanized, cold formed, lipped steel channel horizontal member, not less than 41 by 41 mm (1-5/8 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 13 mm (1/2 inch) galvanized steel bands, or pre-insulated calcium silicate shield for insulated piping at each hanger.

K. 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 pre-insulated calcium silicate shields. Provide Type 40 insulation shield or pre-insulated calcium silicate shield at all other types of supports and hangers including those for pre-insulated 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. Saddle Support: Type 36, 37 or 38.
      e. Turnbuckle: Types 13 or 15. Pre-insulate.
      f. U-bolt Clamp: Type 24.

g. 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.

**2.8 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 (1 inch) above finished floor and provide sealant for watertight joint.
2. For Blocked Out Floor Openings: Provide 38 mm (1-1/2 inch) angle set in silicone adhesive around opening.
3. For Drilled Penetrations: Provide 38 mm (1-1/2 inch) angle ring or square set in silicone adhesive around penetration.

C. Penetrations through beams or ribs are prohibited but may be installed in concrete beam flanges. Any deviation from these requirements shall 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.

**2.9 DUCT PENETRATIONS**

A. Provide curbs for roof mounted piping, ductwork and equipment. Curbs shall be 457 mm (18 inches) high with continuously welded seams, built-in cant strip, interior baffle with acoustic insulation, curb bottom, hinged curb adapter.

B. 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.

**2.10 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 (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 75 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.

**2.12 ASBESTOS**

A. Materials containing asbestos are prohibited.

**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**

A. Location of equipment, access provisions shall be coordinated with the work of all trades. The coordination/shop drawings shall be submitted for review. Locate 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 in 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 is prohibited, except as permitted by COR where working area space is limited.
2. Locate holes to avoid interference with structural members such as slabs, columns, ribs, beams or reinforcing. 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 service are not shown but shall be provided.

G. Electrical Interconnection of Instrumentation or Controls: This generally not shown but shall 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. Install steam piping expansion joints as per manufacturer’s recommendations.

K. Work in Existing Building:

1. Perform as specified in paragraphs OPERATIONS AND STORAGE AREAS, paragraph ALTERATIONS, and paragraph 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, paragraph OPERATIONS AND STORAGE AREAS, make alterations to existing service piping at times that will least interfere with normal operation of the facility.

L. Switchgear/Electrical Equipment Drip Protection: Every effort shall be made to eliminate the installation of pipe above electrical and data/telephone switchgear. 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 not 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 feet) above the equipment or to ceiling structure, whichever is lower (NFPA 70).

M. Inaccessible Equipment:

1. Where the Government determines that the Contractor has installed equipment not conveniently accessible for operation and maintenance or inspections, equipment shall be removed and reinstalled or remedial action performed as directed at no additional cost or time 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, but not limited to motors, fans, pumps, belt guards, transformers, high voltage lines, conduit and raceways, piping, hot surfaces, and ductwork. The COR has final determination on whether an installation meets this requirement or not.

**3.3 TEMPORARY PIPING AND EQUIPMENT**

A. Continuity of operation of existing facilities will generally require temporary installation or relocation of equipment, ducts, 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 paragraph 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 13 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, inline pumps and other heavy components. Provide a support within one foot of each elbow.

E. HVAC Vertical Pipe Supports:

1. Up to 152 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.

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 152 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 in 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.

**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. Refer to Section 09 91 00, 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. 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 gauges and thermometers.

j. Glass.

k. 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. Pumps, fans, motors, steel and cast-iron bases, and coupling guards shall be cleaned, and shall be touched-up with the same paint type and color as utilized by the pump and fan manufacturer.
5. 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.
6. Paint shall withstand the following temperatures without peeling or discoloration:
   a. Condensate and Feedwater: 38 degrees C (100 degrees F) on insulation jacket surface and 121 degrees C (250 degrees F) on metal pipe surface.
   b. Steam: 52 degrees C (125 degrees F) on insulation jacket surface and 190 degrees C (374 degrees F) on metal pipe surface.
7. 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.
8. 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: Refer to Section 09 91 00, PAINTING.

D. Attach ceiling grid label on ceiling grid location directly underneath above ceiling air terminal, control system component, valve, filter unit, fan etc.

**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 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. 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, paragraph 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 paragraph TESTS, and in individual Division 23 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 shall 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. 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 05 12**
**GENERAL MOTOR REQUIREMENTS FOR HVAC EQUIPMENT**

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

A. This section specifies the furnishing, installation and connection of motors for HVAC and steam generation 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 00 00, GENERAL REQUIREMENTS.

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

C. Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.

D. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

E. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

F. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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

H. Section 26 29 11, MOTOR CONTROLLERS.

**1.3 APPLICABLE PUBLICATIONS**

***Note: From the date contract documents are provided, the Contractor shall use the most current published versions of all listed standards and references below.**

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 Bearing Manufacturers Association (ABMA):

9 .....Load Ratings and Fatigue Life for Ball Bearings

11 .....Load Ratings and Fatigue Life for Roller Bearings

C. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):

90.1 .....Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings

D. Institute of Electrical and Electronics Engineers (IEEE):

112 .....Standard Test Procedure for Polyphase Induction Motors and Generators

841 .....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):

MG 1.....Motors and Generators

MG 2.....Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators

250 .....Enclosures for Electrical Equipment (1000 Volts Maximum)

F. National Fire Protection Association (NFPA):

.....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 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 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. Comply with requirements in Paragraph “AS-BUILT DOCUMENTATION” in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

**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 29 11, MOTOR CONTROLLERS; 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 premium efficiency type motors. Unless otherwise specified for a particular application, use electric motors with the following requirements.

D. Single-phase Motors:

1. Motors for centrifugal fans and pumps may be split phase or permanent split capacitor (PSC) type. Provide capacitor-start type for hard starting applications.

a. In order to meet ASHRAE 90.1 requirements, motors for small packaged HVAC equipment may be Electrically Commutated motor (EC type). Motor shall be brushless DC type specifically designed for applications with heavy duty ball bearings and electronic communication. The motor shall be speed controllable down to 20 percent of full speed and 85 percent efficient at all speeds.

E. 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: 208-230/460 volts, dual connection.
      c. Motors, 74.6 kW (100 hp) or greater, connected to 240-volt systems: 230 volts.
      d. Motors, 74.6 kW (100 hp) or greater, connected to 480-volt systems: 460 volts.
      e. Motors connected to high voltage systems (Over 600V): Shall conform to NEMA MG 1 for connection to the nominal system voltage shown in the contract documents.

F. 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.

G. 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.

H. 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 in the contract documents, 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.

I. 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.

J. 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 greater 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.

K. 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.

L. Additional requirements for specific motors, as indicated in the other sections listed in Article, RELATED SECTIONS shall also apply.

M. 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.

| Minimum Premium Efficiencies Open Drip-Proof | | | | Minimum Premium Efficiencies Totally Enclosed Fan-Cooled (TEFC) | | | |
|---|---|---|---|---|---|---|---|
| **Rating kW (hp)** | **1200 RPM** | **1800 RPM** | **3600 RPM** | **Rating kW (hp)** | **1200 RPM** | **1800 RPM** | **3600 RPM** |
| 0.746 (1) | 82.5% | 85.5% | 77.0% | 0.746 (1) | 82.5% | 85.5% | 77.0% |
| 1.12 (1.5) | 86.5% | 86.5% | 84.0% | 1.12 (1.5) | 87.5% | 86.5% | 84.0% |
| 1.49 (2) | 87.5% | 86.5% | 85.5% | 1.49 (2) | 88.5% | 86.5% | 85.5% |
| 2.24 (3) | 88.5% | 89.5% | 85.5% | 2.24 (3) | 89.5% | 89.5% | 86.5% |
| 3.73 (5) | 89.5% | 89.5% | 86.5% | 3.73 (5) | 89.5% | 89.5% | 88.5% |
| 5.60 (7.5) | 90.2% | 91.0% | 88.5% | 5.60 (7.5) | 91.0% | 91.7% | 89.5% |
| 7.46 (10) | 91.7% | 91.7% | 89.5% | 7.46 (10) | 91.0% | 91.7% | 90.2% |
| 11.2 (15) | 91.7% | 93.0% | 90.2% | 11.2 (15) | 91.7% | 92.4% | 91.0% |
| 14.9 (20) | 92.4% | 93.0% | 91.0% | 14.9 (20) | 91.7% | 93.0% | 91.0% |
| 18.7 (25) | 93.0% | 93.6% | 91.7% | 18.7 (25) | 93.0% | 93.6% | 91.7% |
| 22.4 (30) | 93.6% | 94.1% | 91.7% | 22.4 (30) | 93.0% | 93.6% | 91.7% |
| 29.8 (40) | 94.1% | 94.1% | 92.4% | 29.8 (40) | 94.1% | 94.1% | 92.4% |

N. Minimum Power Factor at Full Load and Rated Voltage: 90 percent at 1200 RPM, 1800 RPM, and 3600 RPM. wer 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.

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

| Polyphase Open Motors Average full load efficiency | | | | Capacitor-start capacitor-run and capacitor-start induction run open motors Average full load efficiency | | | |
|---|---|---|---|---|---|---|---|
| **Rating kW (hp)** | **6 poles** | **4 poles** | **2 poles** | **Rating kW (hp)** | **6 poles** | **4 poles** | **2 poles** |
| 0.18 (0.25) | 67.5 | 69.5 | 65.6 | 0.18 (0.25) | 62.2 | 68.5 | 66.6 |
| 0.25 (0.33) | 71.4 | 73.4 | 69.5 | 0.25 (0.33) | 66.6 | 72.4 | 70.5 |
| 0.37 (0.5) | 75.3 | 78.2 | 73.4 | 0.37 (0.5) | 76.2 | 76.2 | 72.4 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0.55 (0.75) | 81.7 | 81.1 | 76.8 | 0.55 (0.75) | 80.2 | 81.8 | 76.2 |

**PART 3 - EXECUTION**

**3.1 INSTALLATION**

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

B. 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.

**3.2 FIELD TESTS**

A. All tests shall be witnessed by the CxA 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 contracting officer or their representative.

**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 shall 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.

**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 shall be tested as part of a greater system.

**3.5 DEMONSTRATION AND TRAINING**

A. Provide services of manufacturer's technical representative for 1 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 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. This section specifies the application of noise control measures, seismic restraints for equipment, tolerance and vibration isolation for HVAC work, and vibration control techniques to boiler plant rotating equipment and parts including chillers, cooling towers, boilers, pumps, fans, compressors, motors, and steam turbines.

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 00 00, GENERAL REQUIREMENTS.

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

C. Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.

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 31 00, HVAC DUCTS and CASINGS.

### 1.3 APPLICABLE PUBLICATIONS

***Note: From the date contract documents are provided, the Contractor shall use the most current published versions of all listed standards and references below.**

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 Civil Engineers (ASCE):

ASCE 7-.....Minimum Design Loads for Buildings and Other Structures

C. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):

Handbook.....ASHRAE Handbook – HVAC Applications

Handbook.....ASHRAE Handbook - Fundamentals, Chapter 8, Sound and Vibration

D. American Society for Testing and Materials (ASTM):

A123/A123M.....Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

A307 .....Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 PSI Tensile Strength

B117 .....Standard Practice for Operating Salt Spray (Fog) Apparatus

D2240.....Standard Test Method for Rubber Property - Durometer Hardness

E. International Code Council (ICC):

IBC .....International Building Code

F. Manufacturers Standardization Society (MSS):

SP-58 .....Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation

G. Occupational Safety and Health Administration (OSHA):

29 CFR 1910.95 .....Occupational Noise Exposure

H. Sheet Metal and Air Conditioning Contractor's National Association (SMACNA):

001 .....Seismic Restraint Manual: Guidelines for Mechanical Systems, 3rd Edition

I. Department of Veterans Affairs (VA):

H-18-8\.....Seismic Design Requirements

PG-18-10\.....HVAC Design Manual

**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 41 NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT** ", 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. Vibration isolators:
    a. Floor mountings
    b. Hangers
2. Bases.
3. Seismic restraint provisions and bolting.

3. Acoustical enclosures.

D. Isolator manufacturer shall furnish with submittal load calculations for selection of isolators, including supplemental bases, based on lowest operating speed of equipment supported.

E. 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 in the contract documents.

**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.

B. Refer to Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS for additional sustainable design requirements.

C. Noise Criteria:

1. Perform an acoustic analysis to demonstrate that the specified room noise levels are achieved in all octave bands for all air-handling units, heating and ventilating units, fans, chillers, boilers, generators, and outdoor noise producing equipment, such as cooling towers and chillers. Refer to VA HVAC Design Manual Chapter 6 Room Data Sheets for the required Noise Criteria (NC) levels. If the necessary room type is not listed in Chapter 6 of VA HVAC Design Manual then consult the ASHRAE Handbook - HVAC Applications. The analysis shall consider both air duct borne noise and noise transmission through walls, floors and roofs and shall be completed for all duct systems and all HVAC equipment.
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 29 CFR 1910.95 requirements are not exceeded. Selection procedure shall be in accordance with ASHRAE Handbook - Fundamentals, Chapter 8, Sound and Vibration.
3. An allowance, not to exceed 5 db, 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.

D. Seismic Restraint Requirements:

1. 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 50 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.
2. Piping: Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
3. Ductwork: Refer to Section 23 31 00, HVAC DUCTS AND CASINGS.

E. Allowable Vibration Tolerances for Rotating, Non-reciprocating Equipment: Not to exceed a self-excited vibration maximum velocity of 5 mm per second (0.20 inch per second) RMS, filter in, when measured with a vibration meter on bearing caps of machine in vertical, horizontal, and axial directions or measured at equipment mounting feet if bearings are concealed. Measurements for internally isolated fans and motors may be made at the mounting feet.

**1.6 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 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. Refer to ASHRAE Handbook - HVAC Applications Chapter 49, Noise and Vibration Control, Table 47 for selection guide for Vibration Isolation.

B. Elastomeric 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. Provide floor mounted equipment with Type SS vibration Isolators. 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. Double Deflection Neoprene (Type N): Shall include neoprene covered steel support plated (top and bottom), friction pads, and necessary bolt holes.
2. 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.
3. 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 are 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.

4. Pads (Type D), Washers (Type W), and Bushings (Type L): Pads shall be natural rubber or neoprene waffle, neoprene and steel waffle, or reinforced duck and neoprene. Washers and bushings shall be reinforced duck and neoprene. Size pads for a maximum load of 345 kPa (50 pounds per square inch).

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.

**2.4 BASES**

A. Rails (Type R): Design rails with isolator brackets to reduce mounting height of equipment and cradle machines having legs or bases that do not require a complete supplementary base. To assure adequate stiffness, height of members shall be a minimum of 1/12 of longest base dimension but not less than 100 mm (4 inches). Where rails are used with neoprene mounts for small fans or close coupled pumps, extend rails to compensate overhang of housing.

**PART 3 - EXECUTION**

**3.1 INSTALLATION**

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. 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 (l00 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.
6. Non-rotating equipment such as heat exchangers and convertors shall be mounted on isolation units having the same static deflection as the isolation hangers or support of the pipe connected to the equipment.

C. 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. Torque anchor bolts according to equipment manufacturer's recommendations to resist seismic forces.

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**SECTION 23 05 93**
**TESTING, ADJUSTING, AND BALANCING FOR HVAC**

## PART 1 - GENERAL

### 1.1 DESCRIPTION

A. A complete listing of common acronyms and abbreviations are included in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

B. 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. Systems Inspection Report.
4. Duct Air Leakage Test Report.
5. Systems Readiness Report.
6. Balancing air and water distribution systems; adjustment of total system to provide design performance; and testing performance of equipment and automatic controls.
7. Recording and reporting results.
8. Document critical paths of flow on reports.

C. Definitions:

1. Basic TAB used in this Section: Chapter 39, "Testing, Adjusting and Balancing" of ASHRAE Handbook "HVAC Applications".
2. TAB: Testing, Adjusting and Balancing; the process of checking and adjusting HVAC systems to meet design objectives.
3. AABC: Associated Air Balance Council.
4. NEBB: National Environmental Balancing Bureau.
5. TABB: Testing Adjusting and Balancing Bureau.
6. SMACNA: Sheet Metal and Air Conditioning Contractors' National Association.
7. Hydronic Systems: Includes chilled water, heating hot water,.
8. Air Systems: Includes all outside air, supply air, return air, exhaust air and relief air systems.
9. Flow Rate Tolerance: The allowable percentage variation, minus to plus, of actual flow rate from values (design) in the contract documents.

### 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.

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 07 11, HVAC AND BOILER PLANT INSULATION.

I. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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

K. Section 23 31 00, HVAC DUCTS AND CASINGS.

L. Section 23 36 00, AIR TERMINAL UNITS.

**1.3 APPLICABLE PUBLICATIONS**

***Note: From the date contract documents are provided, the Contractor shall use the most current published versions of all listed standards and references below.**

A. The following publications 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, Inc. (ASHRAE):

.....ASHRAE Handbook – HVAC Applications, Chapter 39, Testing, Adjusting, and Balancing and Chapter 49, Noise and Vibration Control

C. Associated Air Balance Council (AABC):

.....National Standards for Total System Balance, 7th Edition

D. National Environmental Balancing Bureau (NEBB):

.....Procedural Standard for Testing, Adjusting, and Balancing of Environmental Systems, 9th Edition

.....Procedural Standard for the Measurement of Sound and Vibration, 2nd Edition

S110 .....Whole Building Technical Commissioning of New Construction, 2nd Edition

E. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):

.....HVAC Systems Testing, Adjusting and Balancing, 3rd Edition

.....TAB Procedural Guide 1st 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 XX XX XX, SECTION TITLE", with applicable paragraph identification.

C. 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.

D. For use by the COR staff, submit one complete set of applicable AABC, NEBB or TABB publications that will be the basis of TAB work.

E. Submit the following for review and approval:

1. Design Review Report within 90 days for conventional design projects after the system layout on air and water 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, performance tests, vibration tests and sound 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 branch shall have at least one terminal device damper 100 percent open.

F. Prior to request for Final or Partial Final inspection, submit completed Test and Balance report for the area with noted critical paths.

**1.5 QUALITY ASSURANCE**

A. Refer to paragraphs QUALITY ASSURANCE and SUBMITTALS, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC, Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT and STEAM GENERATION, and Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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 the AABC, TABB or NEBB within the five (5) 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 or TABB or an experienced technician of the Agency certified by NEBB. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason, the Specialist loses subject certification during this period, the 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 the AABC or the NEBB within the five (5) 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 shall be performed by an approved successor.
4. TAB Specialist shall be identified by the General Contractor within sixty (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 shall specifically include:
    a. Directly supervising all TAB work.
    b. 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, TABB or NEBB.
    c. Following all TAB work through its satisfactory completion.
    d. Providing final markings of settings of all HVAC adjustment devices.

e. Permanently mark location of duct test ports.

f. Documenting critical paths from the fan or pump. These critical paths are ones in which are 100 percent 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 shall have done satisfactory work on a minimum of three (3) projects comparable in size and complexity to this project. Qualifications shall be certified by the TAB agency in writing. The lead technician shall be certified by AABC, TABB or NEBB.

C. Test Equipment Criteria: The instrumentation shall meet the accuracy/calibration requirements established by AABC National Standards, TABB/SMACNA International Standards, or by NEBB Procedural Standard 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. All equipment shall remain in calibration, or be re-calibrated if certification expires, during the TAB procedures.

D. TAB Criteria:

1. One or more of the applicable AABC, NEBB, TABB or SMACNA publications, supplemented by Chapter 39, "Testing, Adjusting and Balancing" of ASHRAE Handbook "HVAC Applications" and requirements stated herein shall be the basis for planning, procedures, and reports.

2. Flow Rate Tolerance: Following tolerances are allowed. For tolerances not mentioned herein follow Chapter 39, "Testing, Adjusting and Balancing" of ASHRAE Handbook "HVAC Applications" 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 5 percent to plus l0 percent.

b. Air Terminal Units (maximum values): Minus 5 percent to plus l0 percent

c. Minimum Outside Air: 0 percent to plus 10 percent.

d. 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 air space is 100 CFM or less the tolerance will be minus 5 to plus 5 percent.

f. Hot Water Coils: Minus 5 percent to plus 5 percent.

h. Chilled Water Coils: Minus 5 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 for one air distribution system (including all fans, 3 terminal units, 3 rooms randomly selected by the COR, one of which shall be a critical path) and 1 hydronic system (pumps and 3 coils) as follows:
   a. When field TAB work begins.
   b. During each partial final inspection and the final inspection for the project if requested by VA.

**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 Paragraph 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 documents 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.

**3.3 SYSTEMS INSPECTION REPORT**

A. Inspect equipment and installation for conformance with design.

B. The inspection and report shall be done after air distribution and hydronic equipment is onsite and duct and piping 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 checklist format developed by AABC, NEBB or SMACNA (TABB), 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. Inspect each system to ensure that it is complete including installation and operation of controls. Submit report to COR in standard format and forms prepared and/or approved by the CxA.

B. Verify that all items such as ductwork piping, dampers, valves, ports, terminals, connectors, etc., that are required for TAB are installed. Provide a report to the COR.

**3.6 TAB REPORTS**

A. 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.

B. 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.

C. 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, TABB or NEBB. Balancing shall be done proportionally to all applicable systems.

1. At least 1 trunk damper shall be 100 percent open.
2. At least 1 branch damper shall be 100 percent open per trunk.
3. At least 1 terminal device duct be 100 percent open per branch.
4. At least one hydronic balancing valve shall be 100 percent open per hydronic system.

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. Air Balance and Equipment Test: Include air-handling units, fans, terminal units, fan coil units, room diffusers/outlets/inlets, computer room AC units, and laboratory fume hoods and biological safety cabinets.
   1. Artificially load air filters by partial blanking to produce static air pressure drop of manufacturer's recommended pressure drop.
   2. Adjust fan speeds to provide design air flow.
   3. Test and balance systems in all specified modes of operation, including variable volume, economizer, and fire emergency modes. Verify that dampers and other HVAC controls function properly.

D. Rooms with Specific Pressure Relationships Including Data Center and associated ancillary spaces
   1. For rooms that require specific pressure relationships as noted in the contract documents report the following information:
      a. Room differential pressure at minimum and maximum flows.
      b. Room air changes per hour (ACH).
      c. Adjust airflows to achieve the required air pressure relationships. Increase/decrease the supply/exhaust airflow as needed. For positively pressurized rooms the supply airflow shall be set per the contract documents and return/exhaust airflow shall be adjusted to achieve the required pressure relationship. For negatively pressurized rooms the exhaust airflow per the contract documents and the supply airflow adjusted to achieve the required pressure relationship.

E. Water Balance and Equipment Test: Include circulating pumps, convertors, coils, coolers and condensers:
   1. Coordinate water chiller flow balancing with Section 23 64 00, PACKAGED WATER CHILLERS.
   2. Adjust flow rates for equipment. Set coils and evaporator to values on equipment submittals, if different from values in the contract documents.
   3. 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.

4. 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.
5. On coils with automatic flow limiting valves (automatic balancing valves) measure and report Delta P across valve and measure Delta P across 100 percent open temperature control valve and using control valve CV calculate and report gpm.
6. Record final valve setting for all balancing valves.

**3.7 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.

**3.8 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.

**3.9 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.

**3.10 CRITICAL FLOW PATH**

A. Provide a documented critical path for all fluid flows. There shall be at least one (1) terminal device that can be traced back to the fan or pump where there is no damper or valves that are less than 100 percent open.

**3.11 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.

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**SECTION 23 07 11**
**HVAC INSULATION**

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

A. Field applied insulation for thermal efficiency and condensation control for
   1. HVAC piping, ductwork 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, 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 space, and pipe spaces.
   5. Exposed: Piping, ductwork, and equipment exposed to view in finished areas including mechanical 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. Shafts, chases, interstitial spaces, unfinished attics, crawl spaces and pipe basements are not considered finished areas.
   6. FSK: Foil-scrim-kraft facing.
   7. Hot: HVAC Ductwork handling air at design temperature above 16 degrees C (60 degrees F); HVAC equipment or piping handling media above 41 degrees C (105 degrees F).
   8. Density: $kg/m^3$ - 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.
   11. Flat surface: Watt per square meter (BTU per hour per square foot).
   12. Pipe or Cylinder: Watt per square meter (BTU per hour per linear foot).
   13. Thermal Conductivity (k): Watt per meter, per degree C (BTU per inch thickness, per hour, per square foot, per degree F temperature difference).
   14. 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.

15. HWH: Hot water heating supply.
16. HWHR: Hot water heating return.
17. CW: Cold water.
18. HW: Hot water.
19. CH: Chilled water supply.
20. CHR: Chilled water return.
21. RS: Refrigerant suction.
22. PVDC: Polyvinylidene chloride vapor retarder jacketing, white.

**1.2 RELATED WORK**

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

B. Section 02 82 11, TRADITIONAL ASBESTOS ABATEMENT.

C. Section 07 84 00, FIRESTOPPING.

D. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

E. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

F. Section 23 21 13, HYDRONIC PIPING.

I. Section 23 22 13, STEAM and CONDENSATE HEATING PIPING

**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:

**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*.

**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.)*

**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.

**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

**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.

**4.3.3.3.1** In no case shall the test temperature be below 121°C (250°F).

**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.

**4.3.3.5*** Air duct linings shall be interrupted at fire dampers to prevent interference with the operation of devices.

**4.3.3.6** Air duct coverings shall not be installed to conceal or prevent the use of any service opening.

**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.

**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.

**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.

**4.3.10.2.6.6** Supplementary materials for air distribution systems shall be permitted when complying with the provisions of 4.3.3.

**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**

***Note: From the date contract documents are provided, the Contractor shall use the most current published versions of all listed standards and references below.**

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.):

L-P-535E (2)Plastic Sheet (Sheeting): Plastic Strip; Poly (Vinyl Chloride) and Poly (Vinyl Chloride - Vinyl Acetate), Rigid.

C. Military Specifications (Mil. Spec.):

MIL-A-3316C Adhesives, Fire-Resistant, Thermal Insulation

MIL-A-24179A (1) Adhesive, Flexible Unicellular-Plastic Thermal Insulation

MIL-C-19565C (1)Coating Compounds, Thermal Insulation, Fire-and Water-Resistant, Vapor-Barrier

MIL-C-20079H .....Cloth, Glass; Tape, Textile Glass; and Thread, Glass and Wire-Reinforced Glass

D. American Society for Testing and Materials (ASTM):

A167-99.....Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip

B209 .....Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate

C411 .....Standard test method for Hot-Surface Performance of High-Temperature Thermal Insulation

C449 .....Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement

C534 .....Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form

C547 .....Standard Specification for Mineral Fiber pipe Insulation

C552 .....Standard Specification for Cellular Glass Thermal Insulation

C553 .....Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications

C585 .....Standard Practice for Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System) R (1998)

C612 .....Standard Specification for Mineral Fiber Block and Board Thermal Insulation

C1126 .....Standard Specification for Faced or Unfaced Rigid Cellular Phenolic Thermal Insulation

C1136 .....Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation

E84 .....Standard Test Method for Surface Burning Characteristics of Building Materials

E119 .....Standard Test Method for Fire Tests of Building Construction and Materials

E136 .....Standard Test Methods for Behavior of Materials in a Vertical Tube Furnace at 750 degrees C (1380 F)

E. National Fire Protection Association (NFPA):

90A.....Standard for the Installation of Air Conditioning and Ventilating Systems

96 .....Standards for Ventilation Control and Fire Protection of Commercial Cooking Operations

101 .....Life Safety Code

251 .....Standard methods of Tests of Fire Endurance of Building Construction Materials

255 .....Standard Method of tests of Surface Burning Characteristics of Building Materials

F. Underwriters Laboratories, Inc (UL):

723 **.....**UL Standard for Safety Test for Surface Burning Characteristics of Building Materials with Revision of 09/08

G. Manufacturer's Standardization Society of the Valve and Fitting Industry (MSS):

SP58 .....Pipe Hangers and Supports Materials, Design, and Manufacture

**PART 2 - PRODUCTS**

**2.1 MINERAL FIBER OR FIBER GLASS**

A. ASTM C612 (Board, Block), Class 1 or 2, density 48 kg/m$^3$ (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 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 MINERAL WOOL**

A. Comply with Standard ASTM C612, Class 3, 450 degrees C (850 degrees F).

**2.3 RIGID CELLULAR PHENOLIC FOAM**

A. Preformed (molded) pipe insulation, ASTM C1126, type III, grade 1, k = 0.021(0.15) at 10 degrees C (50 degrees F), for use at temperatures up to 121 degrees C (250 degrees F) with all service vapor retarder jacket with polyvinyl chloride premolded fitting covering.

B. Equipment and Duct Insulation, ASTM C 1126, type II, grade 1, k = 0.021 (0.15) at 10 degrees C (50 degrees F), for use at temperatures up to 121 degrees C (250 degrees F) with rigid cellular phenolic insulation and covering, and all service vapor retarder jacket.

**2.4 CELLULAR GLASS CLOSED-CELL**

A. Comply with Standard ASTM C177, C518, density 120 kg/m$^3$ (7.5 pcf) nominal, k = 0.033 (0.29) at 24~~0~~ 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.

**2.5 FLEXIBLE ELASTOMERIC CELLULAR THERMAL**

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). No jacket required.

**2.6 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. Factory composite materials may be used provided that they have been tested and certified by the manufacturer.

E. 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.

F. Aluminum Jacket-Piping systems: 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.

**2.7 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.

**2.8 MECHANICAL FASTENERS**

A. Staples: Outward clinching monel or galvanized steel.

B. Wire: 1.3 mm thick (18 gage) soft annealed galvanized or 1.9 mm (14 gage) copper clad steel or nickel copper alloy.

C. Bands: 13 mm (0.5 inch) nominal width, brass, galvanized steel, aluminum or stainless steel.

**2.9 REINFORCEMENT AND FINISHES**

A. Glass fabric, open weave: ASTM D1668, Type III (resin treated) and Type I (asphalt treated).

B. Glass fiber fitting tape: Mil. Spec MIL-C-20079, Type II, Class 1.

C. Tape for Flexible Elastomeric Cellular Insulation: As recommended by the insulation manufacturer.

D. Hexagonal wire netting: 25 mm (one inch) mesh, 0.85 mm thick (22 gage) galvanized steel.

E. 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.

F. 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.

**2.10 FIRESTOPPING MATERIAL**

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

**2.11 FLAME AND SMOKE**

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 Resident Engineer 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. Where removal of insulation of piping, ductwork and equipment is required to comply with Section 02 82 11, TRADITIONAL ASBESTOS ABATEMENT and Section 02 82 13.13, GLOVEBAG ASBESTOS ABATEMENT, such areas shall be reinsulated to comply with this specification.

D. 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).

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

F. 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.

G. 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.

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

I. Elbows, flanges and other fittings shall be insulated with the same material as is used on the pipe straights. 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 on cold applications.

J. 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 or duct chase walls and floors
      c. Smoke partitions
      d. Fire partitions

K. Provide vapor barrier jackets over insulation as follows:
   1. All piping and ductwork exposed to outdoor weather.

L. Provide metal jackets over insulation as follows:
   1. All piping and ducts 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 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 millimeters and inches specified in the schedule at the end of this section.

B. Rigid Cellular Phenolic Foam:

1. Rigid closed cell phenolic insulation may be provided for piping, ductwork and equipment for temperatures up to 121 degrees C (250 degrees F).
2. Note the NFPA 90A burning characteristics requirements of 25/50 in paragraph 1.3.B
3. Provide secure attachment facilities such as welding pins.
4. Apply insulation with joints tightly drawn together
5. Apply adhesives, coverings, neatly finished at fittings, and valves.
6. Final installation shall be smooth, tight, neatly finished at all edges**.**
7. Minimum thickness in millimeters (inches) specified in the schedule at the end of this section.
8. 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 maximum water vapor permeance of 0.00 perms.
9. Condensation control insulation: Minimum 25 mm (1.0 inch) thick for all pipe sizes.
   a. HVAC: Cooling coil condensation piping to waste piping fixture or drain inlet. Omit insulation on plastic piping in mechanical rooms.

C. Cellular Glass Insulation:

1. Pipe and tubing, covering nominal thickness in millimeters and inches as specified in the schedule at the end of this section.
2. Underground Piping Other than or in lieu of that Specified in Section 23 21 13, HYDRONIC PIPING and Section 33 63 00, STEAM ENERGY DISTRIBUTION: 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. 75 mm (3 inches) thick for hot water piping.
   b. As scheduled at the end of this section for chilled water piping.
   c. 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.

d. Provide expansion chambers for pipe loops, anchors and wall penetrations as recommended by the insulation manufacturer.

e. Underground insulation shall be inspected and approved by the Resident Engineer as follows:

1) Insulation in place before coating.

2) After coating.

f. Sand bed and backfill: Minimum 75 mm (3 inches) all around insulated pipe or tank, applied after coating has dried.

3. Cold equipment: 50 mm (2 inch) thick insulation faced with ASJ for chilled water pumps, water filters, chemical feeder pots or tanks, expansion tanks, air separators and air purgers.

4. Exposed, unlined supply and return ductwork exposed to outdoor weather: 50 mm (2 inch) thick insulation faced with a reinforcing membrane and two coats of vapor barrier mastic or multi-layer vapor barrier with a water vapor permeability of 0.00 perms.

D. 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 millimeters (inches as specified in the schedule at the end of this section.
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. Use Class S (Sheet), 20 mm (3/4 inch) thick for the following:
   a. Chilled water pumps
   b. Bottom and sides of metal basins for winterized cooling towers (where basin water is heated).
   c. Chillers, insulate any cold chiller surfaces subject to condensation which has not been factory insulated.
   d. Piping inside refrigerators and freezers: Provide heat tape under insulation.
7. 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.

**3.4 PIPE INSULATION SCHEDULE**

Provide insulation for piping systems as scheduled below:

| **Insulation Wall Thickness Millimeters (Inches)** | | | | | |
|---|---|---|---|---|---|
| | | Nominal Pipe Size Millimeters (Inches) | | | |
| Operating Temperature Range/Service | Insulation Material | Less than 25 (1) | 25 – 32 (1 – 1¼) | 38 – 75 (1½ - 3) | 100 (4) and Above |
| | Insulation Wall Thickness Millimeters (Inches) | | | | |
| 38-94 degrees C (100-200 degrees F) (HWH, HWHR) | Mineral Fiber (Above ground piping only) | 38 (1.5) | 38 (1.5) | 50 (2.0) | 50 (2.0) |

| | | | | | |
|---|---|---|---|---|---|
| (37-60 degrees F)<br>(CH, CHR and RS for DX refrigeration) | Rigid Cellular Phenolic Foam | 38 (1.5) | 38 (1.5) | 38 (1.5) | 38 (1.5) |
| (37-60 degrees F)<br>(CH, CHR and RS for DX refrigeration) | Cellular Glass Closed-Cell | 38 (1.5) | 38 (1.5) | 38 (1.5) | 38 (1.5) |
| (37-60 degrees F)<br>(RS for DX refrigeration) | Flexible Elastomeric Cellular Thermal (Above ground piping only) | 38 (1.5) | 38 (1.5) | 38 (1.5) | 38 (1.5) |

- - - E N D - - -

**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. 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 33 23 SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

C. Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS.

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 09 23 DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

### 1.3 SUMMARY

A. This Section includes requirements for commissioning the HVAC systems of the related 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 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 Commissioning Agent.

B. The Facility HVAC 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.

**1.7 APPLICABLE PUBLICATIONS**

***Note: From the date contract documents are provided, the Contractor shall use the most current published versions of all listed standards and references below.**

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):

PG 18-10.....Mission Critical Facilities - DRAFT

PG 18-10.....Life-Safety Protected Facilities - DRAFT

C. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE):

HANDBOOK.....HVAC Applications ASHRAE Handbook, Chapter 39, Testing, Adjusting, and Balancing, Chapter 44, HVAC Commissioning and Chapter 49, Sound and Vibration Control

HANDBOOK.....HVAC Fundamentals ASHRAE Handbook, Chapter 8, Sound and Vibration

D. Associated Air Balance Council (AABC):

7th Edition.....AABC National Standards for Total System Balance

E. National Environmental Balancing Bureau (NEBB):

9th Edition.....Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems

3rd Edition.....Procedural Standards for the Measurement of Sound and Vibration

2nd Edition... Standard for Whole Building Technical Commissioning of New Construction

F. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):

006 .....HVAC Duct Construction Standard – Metal and Flexible Duct

3rd Edition... 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 Sections 23 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 requirements. 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 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 Resident Engineer. 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 requirements.

**3.5 TRAINING OF VA PERSONNEL**

A. Training of the VA operation and maintenance personnel is required in cooperation with the Resident Engineer 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 GENERAL COMMISSIONING REQUIREMENTS. The instruction shall be scheduled in coordination with the VA Resident Engineer after submission and approval of formal training plans. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS and Division 23 Sections for additional Contractor training requirements.

**----- END -----**

**SECTION 23 09 23**
**DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC**

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

A. General Contractor shall provide direct-digital control system(s) as indicated on the project documents, point list, interoperability tables, 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 startup, 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 BACnet workstations, controllers, devices and components shall be listed by BACnet Testing Laboratories. All new BACnet 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.

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 system.
2. Factory-furnished accessory thermostats and sensors furnished with unitary equipment.

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. 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 (split systems,) controls. These include:
   a. Status alarm.
3. Steam trap monitoring system: Monitoring and alarms shall be connected to the ECC via BACnet.

4. Variable frequency drives. These controls, if not native BACnet, will require a BACnet Gateway.

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 |
| Automatic valves | 23 09 23 | 23 | 23 09 23 | 23 09 23 |
| 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 |
| All control system nodes, equipment, housings, enclosures and panels. | 23 09 23 | 23 09 23 | 23 09 23 | 26 |
| Fire/Smoke Dampers | 23 | 23 | 28 31 00 | 28 31 00 |
| Fire Dampers | 23 | 23 | N/A | N/A |
| VFDs | 23 | 26 | 23 09 23 | 26 |
| Refrigerant monitors | 23 | 23 09 23 | 23 09 23 | 26 |
| 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 |
| 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 |
| Starters, HOA switches | 23 | 23 | N/A | 26 |

F. This facility's existing direct-digital control (DDC) system is to be determined and new controller shall be able to be integrated with existing DDC control system. 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.

G. This campus has standardized on an existing standard ASHRAE Standard 135, BACnet/IP Control System supported by a preselected controls service company. This entity is referred to as the "Control System Integrator" in this Section of the technical specifications. The Control system integrator is responsible for ECC system graphics and expansion. It also prescribes control system-specific commissioning/ verification procedures to the contractor administered by this Section of the technical specification. It lastly provides limited assistance to the contractor administered by this Section of the technical specification in its commissioning/verification work.

1. The General Contractor of this project shall directly hire the Control System Integrator in a contract separate from the contract procuring the controls contractor administered by this Section of the technical specifications.
2. The contractor administered by this Section of the technical specifications shall coordinate all work with the Control System Integrator. The contractor administered by this Section of the technical specifications shall integrate the ASHRAE Standard 135, BACnet/IP control network(s) with the Control System Integrator's B-AWS through an Ethernet connection provided by either the Control System Integrator or VA.
3. The contractor administered by this Section of the technical specifications shall provide a peer-to-peer networked, stand-alone, distributed control system. This direct digital control (DDC) system at least shall include one portable operator terminal - laptop, one digital display unit, microprocessor-based controllers, instrumentation, end control devices, wiring, piping, software, and related systems. This contractor is responsible for all device mounting and wiring.
4. Responsibility Table:

| Item/Task | Section 23 09 23 contactor | Control system integrator | VA |
|---|---|---|---|
| ECC expansion | | X | |

| | | | |
|---|---|---|---|
| ECC programming | | X | |
| Devices, controllers, control panels and equipment | X | | |
| Point addressing: all hardware and software points including setpoint, calculated point, data point(analog/ binary), and reset schedule point | X | | |
| Point mapping | | X | |
| Network Programming | X | | |
| ECC Graphics | | X | |
| Controller programming and sequences | X | | |
| Integrity of LAN communications | | | X |
| Electrical wiring | X | | |
| Operator system training | | X | |
| LAN connections to devices | | | X |
| LAN connections to ECC | | | X |
| IP addresses | | | X |
| Overall system verification (Cx) | | X | |
| Controller and system verification | X | | |

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, unless use of pneumatics as motive force is specifically granted in writing by the VA.

**1.2 RELATED WORK**

A. Section 23 21 13, Hydronic Piping.

B. Section 23 22 13, Steam and Condensate Heating Piping.

C. Section 23 31 00, HVAC Ducts and Casings.

D. Section 23 36 00, Air Terminal Units.

E. Section 23 81 00, Decentralized Unitary HVAC Equipment.

F. Section 23 81 23, Computer-Room Air-Conditioners.

G. Section 23 81 43, Air-Source Unitary Heat Pumps.

H. Section 23 84 00, Humidity Control Equipment.

I. Section 26 05 11, Requirements for Electrical Installations.

J. Section 26 05 26, Grounding 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 26 29 11, Motor Starters.

N. Section 28 31 00, Fire Detection and Alarm.

**1.3 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, 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. JPEG: A standardized image compression mechanism stands for Joint Photographic Experts Group, the original name of the committee that wrote the standard.

KK. Local Area Network (LAN): A communication bus that interconnects operator workstation and digital controllers for peer-to-peer communications, sharing resources and exchanging information.

LL. Network Repeater: A device that receives data packet from one network and rebroadcasts to another network. No routing information is added to the protocol.

MM. 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.

NN. 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.

OO. Object: The concept of organizing BACnet information into standard components with various associated properties. Examples include analog input objects and binary output objects.

PP. Object Identifier: An object property used to identify the object, including object type and instance. Object Identifiers must be unique within a device.

QQ. 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.

RR. Operating system (OS): Software, which controls the execution of computer application programs.

SS. 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.

TT. Peripheral: Different components that make the control system function as one unit. Peripherals include monitor, printer, and I/O unit.

UU. 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.

VV. PICS: Protocol Implementation Conformance Statement, describing the BACnet capabilities of a device. All BACnet devices have published PICS.

WW. PID: Proportional, integral, and derivative control, used to control modulating equipment to maintain a setpoint.

XX. Repeater: A network component that connects two or more physical segments at the physical layer.

YY. 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.

ZZ. Sensors: devices measuring state points or flows, which are then transmitted back to the DDC system.

AAA. Thermostats : devices measuring temperatures, which are used in control of standalone or unitary systems and equipment not attached to the DDC system.

**1.4 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 50 miles with technical staff, spare parts inventory for the next five (5) years, and necessary test and diagnostic equipment to support the control systems.
5. The controls subcontractor shall have minimum of three years of experience in design and installation of building automation systems similar in performance to those specified in this Section.
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.

**1.5 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 degrees C (±1 degrees F) |
| Outdoor air temperature | ±1.0 degrees C [±2 degrees F] |
| Dew Point | ±1.5 degrees C [±3 degrees F] |
| Water temperature | ±0.5 degrees C [±1 degrees F] |
| Relative humidity | ±2 percent RH |
| Water flow | ±1 percent of reading |
| Air flow (terminal) | ±10 percent of reading |
| Air flow (measuring stations) | ±5 percent of reading |
| Air pressure (ducts) | ±25 Pa [±0.1 inch wg] |
| Air pressure (space) | ±0.3 Pa [±0.001 inch wg] |
| Water pressure | ±2 percent of full scale *Note 1 |

Note 1: for both absolute and differential pressure

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 inch wg) | 0–1.5 kPa (0–6 inch wg) |
| Air Pressure | ±3 Pa (±0.01 inch wg) | -25 to 25 Pa (-0.1 to 0.1 inch wg) |
| Airflow | ±10 percent of full scale | |
| Space Temperature | ±1.0ºC (±2.0 degrees F) | |
| Humidity | ±5 percent RH | MRI, SPS, PHARMACY |

11. Extent of direct digital control: control design shall allow for at least the points indicated on the points lists on the drawings.

**1.6 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 to monitor and control the facility's building automation system. This remote connection to the facility shall be within two (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 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.

**1.7 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:

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. Control air-supply components, and computations for sizing compressors, receivers and main air-piping, if pneumatic controls are furnished.
5. 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.
6. Sequence of operations for each system and the associated control diagrams. Equipment and control labels shall correspond to those shown on the drawings.
7. Color prints of proposed graphics with a list of points for display.
8. Furnish a BACnet Protocol Implementation Conformance Statement (PICS) for each BACnet-compliant device.
9. 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.
10. 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.
11. Riser diagrams of wiring between central control unit (CCU) and all control panels.

12. Plan drawings showing routing of LAN and locations of control panels, controllers, routers, gateways, ECC, and larger controlled devices.
13. Construction details for all installed conduit, cabling, raceway, cabinets, and similar. Construction details of all penetrations and their protection.
14. 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. As Built Control Drawings:
   1. Furnish three (3) copies of as-built drawings for each control system. The documents shall be submitted for approval prior to final completion.
   2. Furnish one (1) set of applicable control system prints for each mechanical system for wall mounting. The documents shall be submitted for approval prior to final completion.
   3. Furnish one (1) CD-ROM in CAD DWG and/or .DXF format for the drawings noted in subparagraphs above.

H. 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.

I. Submit Performance Report to COR prior to final inspection.

**1.8 INSTRUCTIONS**

A. Instructions to VA operations personnel: Perform in accordance with Article, INSTRUCTIONS, in Specification Section 01 00 00, GENERAL REQUIREMENTS, and as noted below. Contractor shall also video tape instruction sessions noted below.
1. First Phase: Formal instructions to the VA facilities personnel for a total of 8 hours, given in multiple training sessions (each no longer than four hours in length), conducted sometime between the completed installation and prior to the performance test period of the control system, at a time mutually agreeable to the Contractor and the VA.
2. The O/M Manuals shall contain approved submittals as outlined in Article 1.7, SUBMITTALS. The Controls subcontractor will review the manual contents with VA facilities personnel during second phase of training.
3. Training shall be given by direct employees of THE CONTROLS system subcontractor.

**1.9 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 degrees C (65 to 90 degrees F) at a relative humidity of 20 to 80 percent non-condensing.

B. The Controllers used outdoors shall be mounted in NEMA 4 waterproof enclosures, and shall be rated for operation at –40 to 65 degrees C (-40 to 150 degrees 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.

**1.10 APPLICABLE PUBLICATIONS**

***Note: From the date contract documents are provided, the Contractor shall use the most current published versions of all listed standards and references below.**

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):

135 .....BACnet A Data Communication Protocol for Building Automation and Control Networks

147 .....Reducing the Release of Halogenated Refrigerants from Refrigerating and Air-Conditioning Equipment and Systems

C. Federal Communication Commission (FCC):

Rules and Regulations Title 47 Chapter 1-2014 Part 15: Radio Frequency Devices

D. Institute of Electrical and Electronic Engineers (IEEE):

802.3 .....Standard for Ethernet

E. National Fire Protection Association (NFPA):

70 .....National Electric Code

**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 and a portable operator's terminal.
    b. Network computer processing, data storage and BACnet-compliant communication equipment including Servers and digital data processors.
    c. BACnet-compliant routers, bridges, switches, hubs, modems, gateways, interfaces and similar communication equipment.
    d. Active processing BACnet-compliant building controllers connected to other BACnet-compliant controllers together with their power supplies and associated equipment.
    e. Addressable elements, sensors, transducers and end devices.
    f. Third-party equipment interfaces and gateways as described and required by the Contract Documents.
    g. 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. They may also utilize digital wireless technologies as appropriate to the application and if approved by the VA.
3. All necessary telephone lines, 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 startup 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.

**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, BACnet.
   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 MS/TP data link / physical layer protocol is prohibited to the VA 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. 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.

D. 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 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.

**2.5 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.

**2.6 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 percent to 110 percent of nominal voltage rating and shall perform an orderly shutdown below 80 percent. 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 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. 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:
   b. 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.
   c. 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.

**2.7 SENSORS (AIR, WATER AND – TEMPERATURE AND HUMIDITY)**

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: Resistance Temperature Device (RTD) with an integral 4-20 mA or 0-10 VDC transmitter type for all other sensors.
    a. All space sensors shall be equipped with numerical temperature display on sensor cover, and BACnet communication port. Provide a tooled-access cover.
2. Humidity Sensors: Bulk polymer sensing element type.
    a. Room sensors shall have a sensing range of 20 to 80 percent with accuracy of ± 2 to ± 5 percent RH, including hysteresis, linearity, and repeatability.
    b. Continuous Output Signal: 4-20 mA or 0-10 VDC.

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.

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.

CONTROL CABLES

C. 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 Sections 27 05 26 and 26 05 26.
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.

D. 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.

E. 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 00.

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.

F. 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.

G. 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 15 00. 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.

H. 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.

I. Spring Ranges: Range as required for system sequencing and to provide tight shut-off.

J. 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.

K. 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.

L. 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.

**2.8 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 devises 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.

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 15 00, COMMUNICATIONS STRUCTURED 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. 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.

3. 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.

D. Installation of digital controllers and programming:

1. Provide a separate digital control panel for each major piece of equipment, such as air handling unit, chiller, pumping unit 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 chiller, cooling tower, air handling unit, fan, terminal unit, boiler, pumping unit 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 Architect, 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 one 1minute. Control loop trend data shall be instantaneous and the time between data points shall not be greater than one (1) minute.

**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.

**3.5 DEMONSTRATION AND TRAINING**

A. Provide services of manufacturer's technical representative for 4 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.

----- END -----

**SECTION 23 21 13**
**HYDRONIC PIPING**

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

A. Water piping to connect HVAC equipment, including the following:

1. Chilled water and heating hot water and drain piping.

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 00 00, GENERAL REQUIREMENTS.

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

C. Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.

D. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

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 07 11, HVAC INSULATION.

I. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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

K. Section 23 22 13, STEAM AND CONDENSATE HEATING PIPING.

L. Section 23 82 00, CONVECTION HEATING AND COOLING UNITS.

**1.3 APPLICABLE PUBLICATIONS**

***Note: From the date contract documents are provided, the Contractor shall use the most current published versions of all listed standards and references below.**

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):

B1.20.1 ..... Pipe Threads, General Purpose, Inch

B16.3 ..... Malleable Iron Threaded Fittings: Classes 150 and 300

B16.4 ..... Gray Iron Threaded Fittings: (Classes 125 and 250)

B16.5 ..... Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard

B16.9 .....Factory Made Wrought Buttwelding Fittings

B16.11 .....Forged Fittings, Socket-Welding and Threaded

B16.18 .....Cast Copper Alloy Solder Joint Pressure Fittings

B16.22 .....Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings

B16.24 .....Cast Copper Alloy Pipe Flanges, Flanged Fittings, and Valves: Classes 150, 300, 600, 900, 1500, and 2500

B16.39 .....Malleable Iron Threaded Pipe Unions: Classes 150, 250, and 300

B16.42 .....Ductile Iron Pipe Flanges and Flanged Fittings: Classes 150 and 300

B31.9 .....Building Services Piping

B40.100 .....Pressure Gauges and Gauge Attachments

ASME Boiler and Pressure Vessel Code (BPVC):

BPVC Section VIII.....Rules for Construction of Pressure Vessels, Division 1

C. American Society for Testing and Materials (ASTM):

A47/A47M.....Standard Specification for Ferritic Malleable Iron Castings

A53/A53M.....Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

A106/A106M.....Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service

A126 .....Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings

A183 .....Standard Specification for Carbon Steel Track Bolts and Nuts

A216/A216M.....Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service

A307 .....Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 PSI Tensile Strength

A536 .....Standard Specification for Ductile Iron Castings

B62 .....Standard Specification for Composition Bronze or Ounce Metal Castings

B88 .....Standard Specification for Seamless Copper Water Tube

F439 .....Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80

F441/F441M.....Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80

D. American Welding Society (AWS):

B2.1/B2.1M.....Specification for Welding Procedure and Performance Qualification

E. Manufacturers Standardization Society (MSS) of the Valve and Fitting Industry, Inc.:

SP-67 .....Butterfly Valves

SP-70 .....Gray Iron Gate Valves, Flanged and Threaded Ends

SP-71 .....Gray Iron Swing Check Valves, Flanged and Threaded Ends

SP-80 .....Bronze Gate, Globe, Angle, and Check Valves

SP-85 .....Gray Iron Globe and Angle Valves, Flanged and Threaded Ends

SP-110 .....Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends

SP-125 .....Check Valves: Gray Iron and Ductile Iron, In-line, Spring-Loaded, Center-Guided

F. National Fire Protection Association (NFPA):

70 .....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 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 tubing, with specification, class or type, and schedule.
2. Pipe fittings, including miscellaneous adapters and special fittings.
3. Flanges, gaskets and bolting.
4. Couplings and fittings.
5. Valves of all types.
6. Strainers.
7. Flexible connectors for water service.

8. Pipe alignment guides.
9. Expansion joints.
10. All specified hydronic system components.
11. Water flow measuring devices.
12. Gauges.
13. Thermometers and test wells.

D. Manufacturer's certified data report, Form No. U-1, for ASME pressure vessels:

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 and heating hot water system and other piping systems and equipment.

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.

**1.5 QUALITY ASSURANCE**

A. Refer to 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 1-year old.

C. All couplings, fittings, valves, and specialties shall be the products of a single manufacturer.

1. All castings used for coupling housings, fittings, valve bodies, etc., shall be date stamped for quality assurance and traceability.

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.

E. Refer to Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS for additional sustainable design requirements.

**1.6 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 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. Chilled Water, Heating Hot Water, and Vent Piping:
   1. Steel: ASTM A53/A53M Grade B, seamless or ERW, Schedule 40.
   2. Copper Water Tube Option: ASTM B88, Type K or L, hard drawn. Soft drawn tubing, 19 mm (3/4 inch) and larger, shall be used for runouts routed under slab to floor mounted fan coil units.

B. Cooling Coil Condensate Drain Piping:
   1. From Air Handling Units: Copper water tube, ASTM B88, or Type M. Use of PVC piping is prohibited.
   2. From Fan Coil or Other Terminal Units: Copper water tube, ASTM B88, Type M for runouts and Type L for mains.

C. Pipe supports, including insulation shields, for aboveground piping: Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

**2.3 FITTINGS FOR STEEL PIPE**

A. 50 mm (2 inches) and Smaller: Screwed or welded 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. Unions: ASME B16.39.
   5. 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 or flanged 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: Carbon steel machine bolts or studs and nuts, ASTM A307, Grade B.
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.
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 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. 63 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).

**2.6 SCREWED JOINTS**

A. Pipe Thread: ASME B1.20.1.
B. Lubricant or Sealant: Oil and graphite or other compound approved for the intended service.

**2.7 VALVES**

A. Asbestos packing is prohibited.
B. All valves of the same type shall be products of a single manufacturer.
C. Provide chain operators for valves 152 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 (400 psig)(600 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. Gate Valves:
    a. 50 mm (2 inches) and Smaller: MSS SP-80, Bronze, 1034 kPa (150 psig), wedge disc, rising stem, union bonnet.
    b. 63 mm (2-1/2 inches) and Larger: Flanged, outside screw and yoke. MSS SP-70, iron body, bronze mounted, 860 kPa (125 psig) wedge disc.
4. 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. Globe and Angle Valves:
   1. Globe Valves:
      a. 50 mm (2 inches) and Smaller: MSS SP-80, bronze, 1034 kPa (150 psig) Globe valves shall be union bonnet with metal plug type disc.
      b. 63 mm (2-1/2 inches) and Larger: 860 kPa (125 psig), flanged, iron body, bronze trim, MSS SP-85 for globe valves.
   2. Angle Valves:
      a. 50 mm (2 inches) and Smaller: MSS SP-80, bronze, 1034 kPa (150 psig) Angle valves shall be union bonnet with metal plug type disc.
      b. 63 mm (2-1/2 inches) and Larger: 860 kPa (125 psig), flanged, iron body, bronze trim, MSS SP-85 for angle.

F. Check Valves:
   1. Swing Check Valves:
      a. 50 mm (2 inches) and Smaller: MSS SP-80, bronze, 1034 kPa (150 psig), 45-degree swing disc.
      b. 63 mm (2-1/2 inches) and Larger: 860 kPa (125 psig), flanged, iron body, bronze trim, MSS SP-71 for check valves.
   2. 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.

G. Water Flow Balancing Valves: For flow regulation. Provide separate isolation valve.. Valves shall be sized to provide the needed pressure drop in the middle of their throttling range.
   1. Ball or 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. Provide a readout kit including flow meter, readout probes, hoses, flow charts or calculator, and carrying case.

H. Automatic Balancing Control Valves: Factory calibrated to maintain constant flow (plus or minus five percent) over system pressure fluctuations of 28 to 393 kPa (4 to 57 psig). Provide standard pressure taps and 4 sets of capacity charts. Valves shall be line size and be one of the following designs:

1. Gray iron ASTM A126 or brass body rated 1200 kPa (175 psig) at 93 degrees C (200 degrees F), with stainless-steel piston and spring.
2. Brass or ferrous body designed for 2070 kPa (300 psig) service at 121 degrees C (250 degrees F), with corrosion resistant, tamper proof, self-cleaning piston/spring assembly that is easily removable for inspection or replacement.
3. Combination assemblies containing ball type shut-off valves, unions, flow regulators, strainers with blowdown valves and pressure temperature ports shall be acceptable.
4. Provide a readout kit including flow meter, probes, hoses, flow charts and carrying case.

I. Manual Radiator/Convector Valves: Brass, packless, with position indicator.

**2.8 WATER FLOW MEASURING DEVICES**

A. Minimum overall accuracy plus or minus 3 percent over a range of 70 to 110 percent of design flow. Select devices for not less than 110 percent of design flow rate.

B. Venturi Type: Bronze, steel, or cast-iron with bronze throat, with valved pressure sensing taps upstream and at the throat.

C. Wafer Type Circuit Sensor: Cast-iron wafer-type flow meter equipped with readout valves to facilitate the connecting of a differential pressure meter. Each readout valve shall be fitted with an integral check valve designed to minimize system fluid loss during the monitoring process.

D. Self-Averaging Annular Sensor Type: Brass or stainless-steel metering tube, shutoff valves and quick-coupling pressure connections. Metering tube shall be rotatable so all sensing ports may be pointed down-stream when unit is not in use.

E. Insertion Turbine Type Sensor: Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

F. Flow Measuring Device Identification:

1. Metal tag attached by chain to the device.
2. Include meter or equipment number, manufacturer's name, meter model, flow rate factor and design flow rate in gpm.

G. Portable Water Flow Indicating Meters:
   1. Minimum 152 mm (6 inch) diameter dial, forged brass body, beryllium-copper bellows designed for 1200 kPa (175 psig) working pressure at 121 degrees C (250 degrees F).
   2. Bleed and equalizing valves.
   3. Vent and drain hose and two 3 m (10 feet) lengths of hose with quick disconnect connections.
   4. Factory-fabricated carrying case with hose compartment and a bound set of capacity curves showing flow rate versus pressure differential.
   5. Provide 1 portable meter for each range of differential pressure required for the installed flow devices.

H. Permanently Mounted Water Flow Indicating Meters: Minimum 152 mm (6 inch) diameter, or 457 mm (18 inch) long scale, for 120 percent of design flow rate, direct reading in gpm, with 3 valve manifold and 2 shut-off valves.

**2.9 STRAINERS**

A. Basket Type.
   1. Screens: Bronze, Monel metal or 18-8 stainless-steel, free area not less than 2-1/2 times pipe area, with perforations as follows: 1.1 mm (0.045 inch) diameter perforations for 100 mm (4 inches) and larger: 3.2 mm (1/8 inch) diameter perforations.

B. Suction Diffusers: Specified in Section 23 21 23, HYDRONIC PUMPS.

**2.10 FLEXIBLE CONNECTORS FOR WATER SERVICE**

A. Flanged Spool Connector:
   1. Single arch or multiple arch type. Tube and cover shall be constructed of chlorobutyl elastomer with full faced integral flanges to provide a tight seal without gaskets. Connectors shall be internally reinforced with high strength synthetic fibers impregnated with rubber or synthetic compounds as recommended by connector manufacturer, and steel reinforcing rings.
   2. Working pressures and temperatures shall be as follows:
      a. Connector sizes 50 mm to 100 mm (2 inches to 4 inches), 1137 kPa (165 psig) at 121 degrees C (250 degrees F).
      b. Connector sizes 127 mm to 305 mm (5 inches to 12 inches), 965 kPa (140 psig) at 121 degrees C (250 degrees F).

B. Braided Hose: Corrugated-metal inner hose and braided outer shell.

1. Piping Up To 50 mm (2 inches): Bronze hoses and single-braid bronze sheaths with 3102 kPa at 21 degrees C (450 psig at 70 degrees F) and 2344 kPa at 232 degrees C (340 psig at 450 degrees F) ratings.
2. Piping From 65 mm (2-1/2 inches) To 100 mm (4 inches): Stainless-steel hoses and single-braid, stainless-steel sheaths with 2070 kPa at 21 degrees C (300 psig at 70 degrees F) and 1550 kPa at 232 degrees C (225 psig at 450 degrees F) ratings.
3. Piping From 150 mm (6 inches) and Above: Stainless-steel hoses and single-braid, stainless-steel sheaths with 1380 kPa at 21 degrees C (200 psig at 70 degrees F) and 1000 kPa at 315 degrees C (145 psig at 600 degrees F) ratings.

**2.11 EXPANSION JOINTS**

A. Factory built devices, inserted in the pipe lines, designed to absorb axial cyclical pipe movement which results from thermal expansion and contraction. This includes factory-built or field-fabricated guides located along the pipe lines to restrain lateral pipe motion and direct the axial pipe movement into the expansion joints.

B. Manufacturing Quality Assurance: Conform to Expansion Joints Manufacturers Association (EJMA) Standards.

C. Bellows - Internally Pressurized Type:
   1. Multiple corrugations of Type 304 or Type A240-321 stainless-steel.
   2. Internal stainless-steel sleeve entire length of bellows.
   3. External cast-iron equalizing rings for services exceeding 345 kPa (50 psig).
   4. Welded ends.
   5. Design shall conform to standards of EJMA and ASME B31.9.
   6. External tie rods designed to withstand pressure thrust force upon anchor failure if one or both anchors for the joint are at change in direction of pipeline.
   7. Integral external cover.

D. Bellows - Externally Pressurized Type:
   1. Multiple corrugations of Type 304 stainless-steel.
   2. Internal and external guide integral with joint.
   3. Design for external pressurization of bellows to eliminate squirm.
   4. Welded ends.
   5. Conform to the standards of EJMA and ASME B31.9.
   6. Threaded connection at bottom, 25 mm (1 inch) minimum, for drain or drip point.

7. Integral external cover and internal sleeve.

E. Expansion Compensators:

1. Corrugated bellows, externally pressurized, stainless-steel or bronze.
2. Internal guides and anti-torque devices.
3. Threaded ends.
4. External shroud.
5. Conform to standards of EJMA.

F. Expansion Joint (Contractor's Option): 2413 kPa (350 psig) maximum working pressure, steel pipe fitting consisting of telescoping body and slip-pipe sections, PTFE modified polyphenylene sulfide coated slide section, with welded or flanged ends, suitable for axial end movement to 75 mm (3 inch).

G. Expansion Joint Identification: Provide stamped brass or stainless-steel nameplate on each expansion joint listing the manufacturer, the allowable movement, flow direction, design pressure and temperature, date of manufacture, and identifying the expansion joint by the identification number in the contract documents.

H. Guides: Provide factory-built guides along the pipe line to permit axial movement only and to restrain lateral and angular movement. Guides shall be designed to withstand a minimum of 15 percent of the axial force which will be imposed on the expansion joints and anchors. Field-built guides shall be used if detailed in the contract documents.

I. Supports: Provide saddle supports and frame or hangers for heat exchanger. Mounting height shall be adjusted to facilitate gravity return of steam condensate. Construct supports from steel, weld joints.

**2.12 HYDRONIC SYSTEM COMPONENTS**

A. Air Purger: Cast-iron or fabricated steel, 861 kPa (125 psig) water working pressure, for in-line installation.

B. Tangential Air Separator: ASME BPVC Section VIII construction for 861 kPa (125 psig) working pressure, flanged tangential inlet and outlet connection, internal perforated stainless-steel air collector tube designed to direct released air into expansion tank, bottom blowdown connection. Provide Form No. U-1. If scheduled in the contract documents, provide a removable stainless-steel strainer element having 5 mm (3/16 inch) perforations and free area of not less than five times the cross-sectional area of connecting piping.

C. Pressure Reducing Valve (Water): Diaphragm or bellows operated, spring loaded type, with minimum adjustable range of 28 kPa (4 psig) above and below set point. Bronze, brass or iron body and bronze, brass or stainless-steel trim, rated 861 kPa (125 psig) working pressure at 107 degrees C (225 degrees F).

D. Pressure Relief Valve: Bronze or iron body and bronze or stainless-steel trim, with testing lever. Comply with ASME BPVC Section VIII and bear ASME stamp.

E. Automatic Air Vent Valves: Where shown in the contract documents, 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.

F. Buffer tank shall have a capacity as indicated in the contract documents.

**2.13 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, suitable for board mounting. 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.

1. For Condenser Water Suction (Compound): 101 kPa (29.5 inches Hg) to 689 kPa (100 psig).

**2.14 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 (29.5 inches Hg) to 689 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.

**2.15 THERMOMETERS**

A. Mercury or organic liquid filled type, red or blue column, clear plastic window, with 152 mm (6 inch) brass stem, straight, fixed or adjustable angle as required for each in reading.

B. Case: Chrome plated brass or aluminum with enamel finish.

C. Scale: Not less than 228 mm (9 inches), range as described below, 2-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).

**2.16 FIRESTOPPING MATERIAL**

A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

**PART 3 - EXECUTION**

**3.1 INSTALLATION**

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. Install 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 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. 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.

H. Connect piping to equipment as shown in the contract documents. Install components furnished by others such as:

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 INSULATION.

J. 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. See Welder's qualification requirements in paragraph QUALITY ASSURANCE of Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

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 3 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. Solvent Welded Joints: As recommended by the manufacturer.

**3.3 EXPANSION JOINTS (BELLOWS AND SLIP TYPE)**

A. Anchors and Guides: Provide type, quantity and spacing as recommended by manufacturer of expansion joint and as shown. A professional engineer shall verify in writing that anchors and guides are properly designed for forces and moments which will be imposed.

B. Cold Set: Provide setting of joint travel at installation as recommended by the manufacturer for the ambient temperature during the installation.

C. Preparation for Service: Remove all apparatus provided to restrain joint during shipping or installation. Representative of manufacturer shall visit the site and verify that installation is proper.

D. Access: Expansion joints shall be located in readily accessible space. Locate joints to permit access without removing piping or other devices. Allow clear space to permit replacement of joints and to permit access to devices for inspection of all surfaces and for adding.

**3.4 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.

**3.5 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.

**3.6 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 CxA and CORwill 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.

**3.7 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.

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**SECTION 23 21 23**
**HYDRONIC PUMPS**

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

A. Hydronic pumps for heating, ventilating and air conditioning.

B. Definitions:

1. Capacity: (Gallons per minute (gpm) of the fluid pumped.
2. Head: Total dynamic head in feet of the fluid pumped.
3. Flat head-capacity curve: Where the shutoff head is less than 1.16 times the head at the best efficiency point.

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 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.

D. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

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 12, GENERAL MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.

H. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.

I. Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.

J. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

K. Section 23 21 13, HYDRONIC PIPING.

L. Section 26 29 11, MOTOR CONTROLLERS.

**1.3 APPLICABLE PUBLICATIONS**

***Note: From the date contract documents are provided, the Contractor shall use the most current published versions of all listed standards and references below.**

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):

B16.1 .....Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250

C. American Society for Testing and Materials (ASTM):

A48/48M .....Standard Specification for Gray Iron Castings

B62 .....Standard Specification for Composition Bronze or Ounce Metal Castings

**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 23, HYDRONIC 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. Pumps and accessories.
2. Motors and drives.
3. Variable speed motor controllers.

D. Characteristic Curves: Head-capacity, efficiency-capacity, brake horsepower-capacity, and NPSHR-capacity for each pump and for combined pumps in parallel or series service. Identify pump and show fluid pumped, specific gravity, pump speed and curves plotted from zero flow to maximum for the impeller being furnished and at least the maximum diameter impeller that can be used with the casing.

E. 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.

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 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

G. 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. Design Criteria:

1. Pumps design and manufacturer shall conform to Hydraulic Institute Standards.
2. Pump sizes, capacities, pressures, operating characteristics and efficiency shall be as scheduled.
3. Head-capacity curves shall slope up to maximum head at shut-off.. Select pumps near the midrange of the curve, so the design capacity falls to the left of the best efficiency point, to allow a cushion for the usual drift to the right in operation, 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). Provide pumps with non-overloading motors.
4. 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.
5. Provide all pumps with motors, impellers, drive assemblies, bearings, coupling guard and other accessories specified. Statically and dynamically balance all rotating parts.
6. 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. Name plates shall be visible when pumps are insulated.
7. Test all pumps before shipment. The manufacturer shall certify all pump ratings.
8. After completion of balancing, provide replacement of impellers or trim impellers to provide specified flow at actual pumping head, as installed.

B. Allowable Vibration Tolerance for Pump Units: Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.

C. 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 section. For more information regarding the product categories covered by the Bio-Preferred Program, visit http://www.biopreferred.gov.

D. Refer to Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS for additional sustainable design requirements.

**1.6 AS-BUILT DOCUMENTATION**

A. Comply with requirements in paragraph AS-BUILT DOCUMENTATION of Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

**1.7 SPARE MATERIALS**

A. Furnish one spare seal and casing gasket for each pump to the COR.

**PART 2 - PRODUCTS**

**2.1** Automatic condensate pump units

A. Packaged units with corrosion-resistant pump, plastic tank with cover, and automatic controls. Collects and removes condensate from fan coil units, air handling units, condensing boilers, and similar components. Include factory- or field-installed check valve and 1829 mm (72 inch) minimum, electrical power cord with plug.

**PART 3 - EXECUTION**

**3.1 INSTALLATION**

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. Follow manufacturer's written instructions for pump mounting and startup. Access/Service space around pumps shall not be less than minimum space recommended by pumps manufacturer.

C. Provide drains for bases and seals for base mounted pumps, piped to and discharging into floor drains.

D. Coordinate location of thermometer and pressure gauges as per Section 23 21 13, HYDRONIC PIPING.

**3.2 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. Verify that the piping system has been flushed, cleaned and filled.
E. Lubricate pumps before startup.
F. Prime the pump, vent all air from the casing and verify that the rotation is correct. To avoid damage to mechanical seals, never start or run the pump in dry condition.
G. Verify that correct size heaters-motor over-load devices are installed for each pump controller unit.
H. Field modifications to the bearings and or impeller (including trimming) are prohibited. If the pump does not meet the specified vibration tolerance, send the pump back to the manufacturer for a replacement pump. All modifications to the pump shall be performed at the factory.
I. Ensure the disposable strainer is free of debris prior to testing and balancing of the hydronic system.
J. After several days of operation, replace the disposable startup strainer with a regular strainer in the suction diffuser.

**3.3 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.

**3.4 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.

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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. A complete listing of common acronyms and abbreviated 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 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.

D. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

E. Section 09 91 00, PAINTING.

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 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.

I. Section 23 07 11, HVAC INSULATION.

J. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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

L. Section 23 22 23, STEAM CONDENSATE PUMPS.

M. Section 23 25 00, HVAC WATER TREATMENT.

**1.3 APPLICABLE PUBLICATIONS**

***Note: From the date contract documents are provided, the Contractor shall use the most current published versions of all listed standards and references below.**

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):

B1.20.1 ..... Pipe Threads, General Purpose (Inch)

B16.5 ..... Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard

B16.9 ..... Factory Made Wrought Buttwelding Fittings

B16.11 ..... Forged Fittings, Socket-Welding and Threaded

B16.42 ..... Ductile Iron Pipe Flanges and Flanged Fittings: Classes 150 and 300

B31.1 ..... Power Piping

B31.9 ..... Building Services Piping

B40.100 ..... Pressure Gauges and Gauge Attachments

C. American Society for Testing and Materials (ASTM):

A53/A53M ..... Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

A106/A106M ..... Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service

A193/194M ..... Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications

A194/194M ..... Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both

A216/A216M ..... Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service

A285/A285M ..... Standard Specification for Pressure Vessel Plates, Carbon Steel, Low-and Intermediate-Tensile Strength

A307 ..... Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 PSI Tensile Strength

A516/A516M ..... Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service

A536 ..... Standard Specification for Ductile Iron Castings

B62 ..... Standard Specification for Composition Bronze or Ounce Metal Castings

D. American Welding Society (AWS):

B2.1/B2.1M ..... Specification for Welding Procedure and Performance Qualifications

Z49.1 ..... Safety in Welding and Cutting and Allied Processes

E. Manufacturers Standardization Society (MSS) of the Valve and Fitting Industry, Inc.:

SP-80 ..... Bronze Gate, Globe, Angle, and Check Valves

F. Military Specifications (Mil. Spec.):

MIL-DTL-901E.....Shock Tests, H.I. (High Impact) Shipboard Machinery, Equipment, and Systems

G. National Board of Boiler and Pressure Vessel Inspectors (NB):

Relieving Capacities of Safety Valves and Relief Valves

H. Tubular Exchanger Manufacturers Association (TEMA):

TEMA Standards.....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 23 22 13, STEAM AND CONDENSATE HEATING 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. 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. Valves of all types.
6. Steam traps.
7. Strainers.
8. Pipe alignment guides.
9. Flexible ball joints: Catalog sheets, performance charts, schematic drawings, specifications and installation instructions.
10. All specified steam system components.
11. Gauges.
12. Thermometers and test wells.
13. Seismic bracing details for piping.

D. Coordination Drawings: Refer to paragraph, SUBMITTALS of Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

E. As-Built Piping Diagrams: Provide drawing as follows for steam and steam condensate piping and other central plant equipment.

1. One wall-mounted stick file for prints. Mount stick file in the chiller plant or adjacent control room along with control diagram stick file.
2. One set of reproducible drawings.

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. 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 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. 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:

1. Qualify welding processes and operators for piping according to ASME BPVC Section IX, AWS Z49.1 and AWS B2.1/B2.1M.
2. Comply with provisions in ASME B31.9 or ASME B31.1.
3. 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.
4. All welds shall be stamped according to the provisions of the American Welding Society.

D. ASME Compliance: Comply with ASME B31.9 or ASME B31.1 for materials, products, and installation. Safety valves and pressure vessels shall bear appropriate ASME labels.

**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, VA approved substitutions and construction revisions shall be 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 2023 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 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, seamless or ERW; ASTM A106/A106M Grade B, seamless; Schedule 40.

B. Steam Condensate and Pumped Condensate Piping: Steel, ASTM A53/A53M, Grade B, seamless or ERW; or ASTM A106/A106M Grade B, seamless, Schedule 80.

C. Vent Piping: Steel, ASTM A53/A53M, Grade B, seamless or ERW; ASTM 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. Forged steel, socket welding or threaded: ASME B16.11, 13, 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.
3. Unions: Forged steel, 13, 2000 psig class or 20, 3000 psig class on piping 2 inches and less.
4. Steam line drip station and strainer quick-couple blowdown hose connection: Straight through, plug and socket, screw or cam locking type for 1/2 inch ID hose. No integral shut-off is required.

B. 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 750 degrees F and 1500 psig.

b. Flange bolting: Carbon steel machine bolts or studs and nuts, ASTM A193/193M, Class 2, Grade B7 for bolts and ASTM A194/194M for nuts.

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 gauge connections.

**2.4 DIELECTRIC FITTINGS**

A. Provide where dissimilar metal pipe are joined.

B. 2 inches and Smaller: Threaded dielectric union.

C. 2-1/2 inches and Larger: Flange union with dielectric gasket and bolt sleeves, ASME B16.42.

D. Temperature Rating, 250 degrees F for steam condensate and as required for steam service.

E. Contractor's option: On pipe sizes 2 inches and smaller, screwed end steel gate valves or dielectric nipples may be used in lieu of dielectric unions.

**2.5 VALVES**

A. Asbestos packing is prohibited.

B. All valves of the same type shall be products of a single manufacturer.

C. Provide chain operators for valves 6 inches and larger when the centerline is located 7 feet or greater above the floor or operating platform.

D. Shut-Off Valves:

1. Gate Valves:

a. 50 mm (2 inches) and smaller: Forged steel body, rated for 200 psig saturated steam, 400 psig WOG, bronze wedges and Monel or stainless-steel seats, threaded ends, rising stem, and union bonnet.

b. 2-1/2 inches and larger: Flanged, outside screw and yoke.

1) High pressure steam 16 psig and above system: Cast steel body, ASTM A216/A216M grade WCB, 150 psig at 500 degrees F, 11-1/2 to 13 percent chrome stainless steel solid disc and seats. Provide 1 inch factory installed bypass with globe valve on valves 4 inches and larger.

2) All other services: Forged steel body, Class B, rated for 123 psig saturated steam, 200 psig WOG, bronze or bronze face wedge and seats, 123 psig ASME flanged ends, OS&Y, rising stem, bolted bonnet, and renewable seat rings.

E. Ball Valves: Reduced port permitted for bypass (throttling) service; full port required for all other services, one-fourth turn to open.
   1. Type 501: Type 316 stainless steel body, ball and stem, rated for 150 psig at 365 degrees F, 600 psig at 200 degrees F; reinforced TFE seat, stem seal and thrust washer; end entry, threaded ends.
   2. Type 502: Steel body, rated for 150 psig at 365 degrees F, 250 psig at 250 degrees F, reinforced TFE seat, stem seal and thrust washer; end entry, threaded ends, UL-listed for natural or LP gas shut off service when used on those services.
   3. Type 503: Carbon steel body, steam service, rated for 200 psig at 392 degrees F, stainless steel ball and stem, Polyfil seat, live-loaded or adjustable stem seal, threaded ends.

F. Globe and Angle Valves:
   1. Globe Valves:
      a. 2 inches and smaller: Forged steel body, rated for 200 psig saturated steam, 400 psig WOG, hardened stainless steel disc and seat, threaded ends, rising stem, union bonnet, and renewable seat rings.
      b. 2-1/2 inches and larger:
         1) Globe valves for high pressure steam 16 psig: Cast steel body, ASTM A216/A216M grade WCB, flanged, OS&Y, 150 psig at 500 degrees F, 11-1/2 to 13 percent chrome stainless steel disc and renewable seat rings.
         2) All other services: Steel body, rated for 123 psig saturated steam, 200 psig WOG, bronze or bronze-faced disc (Teflon or composition facing permitted) and seat, 123 psig ASME flanged ends, OS&Y, rising stem, bolted bonnet, and renewable seat rings.
   2. Angle Valves:
      a. 2 inches and smaller: Cast steel 150 psig, union bonnet with metal plug type disc.
      b. 2-1/2 inches and larger:
         1) Angle valves for high pressure steam 16 psig: Cast steel body, ASTM A216/A216M grade WCB, flanged, OS&Y, 150 psig at 500 degrees F, 11-1/2 to 13 percent chrome stainless steel disc and renewable seat rings.
         2) All other services: 125 psig, flanged, cast steel body, and bronze trim.

G. Swing Check Valves:
   1. 2 inches and smaller: Cast steel, 150 psig, 45-degree swing disc.

2. 2-1/2 inches and Larger:
    a. Check valves for high pressure steam 16 psig and above system: Cast steel body, ASTM A216/A216M grade WCB, flanged, OS&Y, 150 psig at 500 degrees F, 11-1/2 to 13 percent chrome stainless steel disc and renewable seat rings.
    b. All other services: 125 psig, flanged, cast steel body, and bronze trim.

H. Manual Radiator/Convector Valves: Brass, packless, with position indicator.

**2.6 STRAINERS**

A. Basket or Y Type. Tee type is acceptable for gravity flow and pumped steam condensate service.

B. High Pressure Steam: Rated 150 psig saturated steam.
    1. 2 inches and smaller: Cast steel, rated for saturated steam at 150 psig threaded ends.
    2. 2-1/2 inches and larger: Cast steel rated for 150 psig saturated steam with 150 psig ASME flanged ends or forged steel with 250 psig ASME flanged ends.

C. All Other Services: Rated 125 psig saturated steam.
    1. 2 inches and smaller: Cast steel body.
    2. 2-1/2 inches and larger: Flanged, cast steel body.

D. Screens: Bronze, Monel metal or 18-8 stainless steel, free area not less than 2-1/2 times pipe area, with perforations as follows:
    1. 3 inches and smaller: 20 mesh for steam and 0.045 inch diameter perforations for liquids.
    2. 4 inches and larger: 0.045 inch diameter perforations for steam and 1/8 inch diameter perforations for liquids.

**2.7 PIPE ALIGNMENT**

A. Guides: Provide factory-built guides along the pipe line to permit axial movement only and to restrain lateral and angular movement. Guides shall be designed to withstand a minimum of 15 percent of the axial force which will be imposed on the expansion joints and anchors. Field-built guides may be used if detailed in the contract documents.

**2.8 FLEXIBLE BALL JOINTS**

A. Design and Fabrication: One-piece component construction, fabricated from steel with welded ends, designed for a working steam pressure of 250 psig and a temperature of 450 degrees F. Each joint shall provide for 360 degrees rotation in addition to a minimum angular flexible movement of 30 degrees for sizes 1/4 inch to 6 inch inclusive, and 15 degrees for sizes 2-1/2 inches to 30 inches. Joints through 14 inches shall have forged pressure retaining members, while size 16 inches through 30 inches shall be of one-piece construction.

B. Material:
   1. Cast or forged steel pressure containing parts and bolting in accordance with ASME BPVC Section II or ASME B31.1. Retainer may be ductile iron ASTM A536, Grade 65-45-12, or ASME BPVC Section II SA 515, Grade 70.
   2. Gaskets: Steam pressure molded composition design for a temperature range of from minus 50 degrees F to plus 525 degrees F.

C. Certificates: Submit qualifications of ball joints in accordance with the following test data:
   1. Low pressure leakage test: 6 psig saturated steam for 60 days.
   2. Flex cycling: 800 Flex cycles at 500 psig saturated steam.
   3. Thermal cycling: 100 saturated steam pressure cycles from atmospheric pressure to operating pressure and back to atmospheric pressure.
   4. Environmental shock tests: Forward certificate from a recognized test laboratory, that ball joints of the type submitted has passed shock testing in accordance with Mil. Spec MIL-S-901.
   5. Vibration: 170 hours on each of three mutually perpendicular axes at 25 to 125 Hz; 0.05 inch to 0.10 inch double amplitude on a single ball joint and 3 ball joint off set.

**2.9 STEAM SYSTEM COMPONENTS**

A. Safety Valves and Accessories: Comply with ASME BPVC Section VIII. Capacities shall be certified by National Board of Boiler and Pressure Vessel Inspectors, maximum accumulation 10 percent. Provide lifting lever. Provide drip pan elbow where shown. Valve shall have stainless steel seats and trim.

B. Steam Trap: Each type of trap shall be the product of a single manufacturer. Provide trap sets at all low points and at 200 feet intervals on the horizontal main lines.
   1. Floats and linkages shall provide sufficient force to open trap valve over full operating pressure range available to the system. Unless otherwise indicated in the contract documents, traps shall be sized for capacities indicated at minimum pressure drop as follows:
      a. For equipment with modulating control valve: 1/4 psig, based on a condensate leg of 12 inches at the trap inlet and gravity flow to the receiver.
      b. For main line drip trap sets and other trap sets at steam pressure: Up to 70 percent of design differential pressure. Condensate may be lifted to the return line.

2. Trap bodies: Steel and stainless-steel, constructed to permit ease of removal and servicing working parts without disturbing connecting piping. The use of raised face flange is required on pipe sizes 1-1/2 inch and greater. The use of unions is acceptable for pipe sizes less than 1–1/2 inches. For systems without relief valve traps shall be rated for the pressure upstream of the steam supplying the system.
3. Balanced pressure thermostatic elements: Phosphor bronze, stainless steel or Monel metal.
4. Valves and seats: Suitable hardened corrosion resistant alloy.
5. Mechanism: Brass, stainless steel or corrosion resistant alloy.
6. Floats: Stainless steel.
7. Inverted bucket traps: Provide bi-metallic thermostatic element for rapid release of non-condensables.
8. Thermodynamic steam traps: Shall have tight shut-off with no steam loss allowed either by bleed or “controlled leak” and shall have an integral seat design with hardened disc and seating surfaces. Thermodynamic traps for steam pressures below 600 psi shall be all stainless-steel construction with threaded, socket weld or flanged connections on a common centerline, and shall be capable of operating in any position. Traps shall be capable of operating with up to 80% back pressure and shall be standard with insulating cover to reduce heat loss. Thermodynamic traps for steam pressures 600 psi or higher shall be of alloy steel construction with threaded, socket weld or flanged connections on a common centerline, and will operate in any position. Steam trap shall be capable of operating with up to 80% back pressure with operating pressure up to 900 psi. Thermodynamic trap shall have three equidistant discharge ports between seat land surfaces to minimize disc and seat wear.

C. Thermostatic Air Vent (Steam): Steel body, balanced pressure bellows, stainless steel (renewable) valve and seat, rated 125 psig working pressure, 3/4 inch)screwed connections. Air vents shall be balanced pressure type that responds to steam pressure-temperature curve and vents air at any pressure.

D. Clean Steam Generator for HVAC Humidification: Factory fabricated; UL listed heat exchanger for the generation of low-pressure clean steam to be used in HVAC humidification. Compatible with softened water.
   1. Electric immersion heated humidifier: 304 stainless steel tank with removable 304 stainless steel cover with gasketed flanges, heater / cover interlock safety switch, power and control wiring terminal strip, steam outlet at top for hose or pipe connection. Factory insulated.
      a. Immersion heater(s): Heater(s) shall be Incoloy alloy-sheathed resistance type designed for no more than 86 watts per square inch. Two threaded ends of each heater element shall pass through the top of the evaporating chamber and be secured and sealed with washer and threaded nuts to evaporating chamber
      b. Temperature sensor: A factory mounted sensor, with a temperature range of -40 to 248 °F (-40 to 120 °C) shall be mounted on the humidifier to maintain evaporating chamber water temperature above freezing.
      c. Over-temperature switch: A factory-mounted and -wired UL-listed limit control sensor with manual reset shall sense an over-temperature condition and de-energize heater circuit controls.
      d. Indoor Mounting: Humidifier shall be mounted on factory furnished, field installed legs.
      e. Drain Positive drainage/blow-down using a drain pump, drawing water from the bottom of the tank, maximizing mineral evacuation.
      f. Steam trap and strainer: Humidifier shall include a float/thermostatic steam trap and steam supply line strainer.
      g. Water requirements: The humidifier shall be capable of generating steam from softened.
   2. Integral water tempering device: A factory-installed thermostatically controlled water valve shall meter an amount of cold water into a stainless-steel mixing chamber to temper 212 degrees F (100 degrees C) water with a 6 gpm (0.38 liter/second) in-flow rate to a 140 degrees F (60 degrees C) discharge temperature to sanitary system.
   3. Controls: Control subpanel shall be factory-attached to humidifier with all wiring between subpanel and humidifier completed at factory. A wiring diagram shall be included. The controller shall be microprocessor based and shall have the following features or functions:
      a. Web interface shall have same functionality as the unit keypad/display and shall allow multiple remotely located users to simultaneously view system operation and/or change

system parameters. Web interface shall have password-protected secure access and shall be compatible with standard Internet browsers. Web interface shall connect directly to a personal computer or through a system network via Ethernet cable and shall be interoperable with any communication network.

b. Redundant low water safety control.

c. Fully modulating (0 to 100 percent) control of humidifier outputs.

d. Water level control: Automatic refill, low water cut-off, field adjustable skimmer bleed-off functions, and automatic drain-down of humidifier.

e. Temperature sensor: A factory mounted sensor, with a temperature range of -40 to 121 degrees C (-40 to 250 degrees F) mounted on the humidifier to enable the following functions:

   1) Maintain the evaporating chamber water temperature above freezing.

   2) Maintain a user-defined preset evaporating chamber water temperature.

   3) Allow rapid warm-up of water in evaporating chamber after a call for humidity, providing 100% operation until steam production occurs.

f. USB port on the control board for software updates, data backups, and data restoration.

g. Up-time optimizer function to keep humidifier(s) operating through conditions such as fill, drain, or run-time faults, as long as safety conditions are met, minimizing production down-time.

h. Real-time clock to allow time-stamped alarm/message tracking, and scheduled events.

i. Factory commissioning of humidifier and control board, including system configuration as-ordered, factory unit testing, and operation with water before shipping.

j. Unit-mounted keypad/display operable within a temperature range of 0 to 70 degrees C (32 to 158 degrees F) and provides backlighting for viewing in low light.
   Alarms, unit configuration, and usage timer values shall remain in nonvolatile memory indefinitely during a power outage.

k. The controls shall monitor, control, and/or adjust the following parameters:

   1) Relative humidity (RH) set point, actual conditions in the space (from humidity transmitter), RH offset.

   2) Dew point set point, actual conditions in the space (from dew point transmitter), dew point offset.

   3) Relative humidity (RH) duct high limit set point (switch) and actual conditions.

4) Relative humidity (RH) duct high limit set point, actual conditions (from transmitter), high limit span, and high limit offset.
5) Total system demand in % of humidifier capacity.
6) Total system output in kg/hr (lb/hr).
7) Drain/flush duration, allowed days, and frequency based on usage.
8) End-of-season drain status (on standard water systems and if ordered as a DI water option) and hours humidifier is idle before end of season draining occurs.
9) Window glass surface temperature in percent RH offset application using separate sensor with programmable offset.
10) Air temperature or other auxiliary temperature monitoring with programmable offset using separate sensor.
11) System alarms and system messages, current and previous.
12) Adjustable water skim duration.

l. Programmable outputs for remote signaling of alarms and/or messages, device activation (such as a fan), or for signaling tank heating and/or steam production.
m. System diagnostics that include:
1) Test outputs function to verify component operation.
2) Test humidifier function by simulating demand to validate performance.
3) Data collection of RH, air temperature, water use, energy use, alarms, and service messages for viewing from the keypad/display or Web interface.
4) Service notification scheduling.
5) Password-protected system parameters.
6) Keypad/display or Web interface displays in English.
7) Numerical units displayed in inch-pound or SI units.

4. Other humidifier control features:
a. Interoperability using BACnet MS/TP.
b. Access panel interlock switch: The control subpanel shall have an interlock control switch with manual override to remove control voltage when access panel is opened.
c. Removable keypad/display: Provide a keypad/display with cable for remote use.
d. Control input accessory:
1) Cold snap offset transmitter: A window surface temperature transmitter, operating temperature range -29 to 71 degrees C (-20 to 160 degrees F), shall be provided for

field installation. Transmitter shall supply its signal (4 to 20 mA) to the microprocessor control system, which shall lower the indoor RH set point to a level 5 percent or greater below the dew point temperature during a cold spell, thus preventing window condensation. The indoor RH shall be automatically returned to the normal setting when the glass temperature rises.

2) Airflow proving switch, pressure type: Airflow proving switch shall be diaphragm-operated with pitot tube for field installation. Switch shall have an adjustable control point range of 12.5 to 2988 Pa (0.05 to 12 inch WG) Operating temperature range -40 to 82 degrees C (-40 to 180 degrees F). Compatible with 24, 120, and 240 VAC.

3) Airflow proving switch, sail type: Airflow proving switch shall be a sail operated electric switch for field installation. Switch makes at 1.3 meter/second (250 feet per minute), breaks at 0.4 meter/second (75 feet per minute). Maximum operating temperature for sail: 77 degrees C (170 degrees F). Maximum operating temperature for switch: 52 degrees C (125 degrees F).

5. Distribution Manifold: Stainless steel, composed of dispersion pipe and surrounding steam jacket, manifold shall span the width of duct or air handler, and shall be multiple manifold type under any of the following conditions:
6. Duct section height exceeds 900 mm (36 inches).
7. Duct air velocity exceeds 5.1 m/s (1000 feet per minute).
8. If within 900 mm (3 feet) upstream of fan, damper or pre-filter.
9. If within 3 m (10 feet) upstream of after-filter.

**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 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 1 inch) in 12 meter 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.

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. 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.

J. Pipe vents to the exterior. Where a combined vent is provided, the cross-sectional area of the combined vent shall be equal to sum of individual vent areas. Slope vent piping 1 inch in 40 feet 0.25 percent in direction of flow. Provide a drip pan elbow on relief valve outlets if the vent rises to prevent backpressure. Terminate vent minimum 12 inches above the roof or through the wall minimum 8 feet above grade with down turned elbow.

K. 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 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 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 32 degrees F or lower, the pipe shall be heated to

approximately 100 degrees F for a distance of 1 foot on each side of the weld before welding, and the weld shall be finished before the pipe cools to 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 shall 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 shall 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 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 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 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 1-1/2inch 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 shall 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.

**3.9 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.

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**SECTION 23 23 00**
**REFRIGERANT PIPING**

## PART 1 - GENERAL

### 1.1 DESCRIPTION

A. Field refrigerant piping for direct expansion HVAC systems.

B. Refrigerant piping shall be sized, selected, and designed either by the equipment manufacturer or in strict accordance with the manufacturer's published instructions. Where there is a discrepancy between the manufacturer requirements and the pipe sizes shown on the drawings, the manufacturer requirements shall govern. 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.

C. A complete listing of common acronyms and abbreviations are included in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

D. Definitions:

1. 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.
    a. Low side means the parts of a refrigerating system subjected to evaporator pressure.
    b. High side means the parts of a refrigerating system subjected to condenser pressure.
2. 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.

### 1.2 RELATED WORK

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

B. Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.

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 07 11, HVAC, and BOILER PLANT INSULATION.

F. Section 23 21 13, HYDRONIC PIPING.

G. Section 23 81 00, DECENTRALIZED UNITARY HVAC EQUIPMENT

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

I. Section 23 81 43, AIR-SOURCE UNITARY HEAT PUMPS

**1.3 APPLICABLE PUBLICATIONS**

***Note: From the date contract documents are provided, the Contractor shall use the most current published versions of all listed standards and references below.**

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. Air Conditioning, Heating, and Refrigeration Institute (ARI/AHRI):

495 .....Standard for Refrigerant Liquid Receivers

730 .....Flow Capacity Rating of Suction-Line Filters and Suction-Line Filter-Driers

750 .....Thermostatic Refrigerant Expansion Valves

760 .....Performance Rating of Solenoid Valves for Use with Volatile Refrigerants

C. American Society of Heating Refrigerating and Air Conditioning Engineers (ASHRAE):

15 .....Safety Standard for Refrigeration Systems (ANSI)

17 .....Method of Testing Capacity of Thermostatic Refrigerant Expansion Valves (ANSI)

34 .....Designation and Classification of Refrigerants (ANSI)

63.2 .....Method of Testing Liquid Line Filter Drier Filtration Capability (ANSI)

D. American National Standards Institute (ANSI):

A13.1 .....Scheme for Identification of Piping Systems

Z535.1 .....Safety Color Code

E. American Society of Mechanical Engineers (ASME):

B16.22 .....Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings (ANSI)

B16.24 .....Cast Copper Alloy Pipe Flanges and Flanged Fittings, Class 150, 300, 400, 600, 900, 1500 and 2500 (ANSI)

B31.5 .....Refrigeration Piping and Heat Transfer Components (ANSI)

B40.100 .....Pressure Gauges and Gauge Attachments

B40.200 .....Thermometers, Direct Reading and Remote Reading

F. American Society for Testing and Materials (ASTM)

B32 .....Standard Specification for Solder Metal

B88 .....Standard Specification for Seamless Copper Water Tube

B88M.....Standard Specification for Seamless Copper Water Tube (Metric)

B280 .....Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service

G. American Welding Society, Inc. (AWS): Brazing Handbook

A5.8/A5.8M.....Standard Specification for Filler Metals for Brazing and Braze Welding

H. Underwriters Laboratories (UL):

207 .....Standard for Refrigerant-Containing Components and Accessories, Nonelectrical

429 .....Standard for Electrically Operated Valves

I. Department of Veterans Affairs (VA):

PG-18-10 .....HVAC Design Manual

**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 23 00, REFRIGERAN PIPING”, with applicable paragraph identification.

C. Shop Drawings:

1. Complete information for components noted, including valves and refrigerant piping accessories, clearly presented, shall be included to determine compliance with in the contract documents for components noted below:
    a. Tubing and fittings
    b. Valves
    c. Strainers
    d. Moisture-liquid indicators
    e. Filter-driers
    f. Flexible metal hose
    g. Liquid-suction interchanges

h. Oil separators (when specified)

i. Gauges

j. Pipe and equipment supports

k. Refrigerant and oil

l. Pipe/conduit roof penetration cover

m. 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.

D. Certification: Copies of certificates for welding procedure, performance qualification record and list of welders' names and symbols.

E. Design Manual: Furnish two copies of design manual of refrigerant valves and accessories.

**1.5 QUALITY ASSURANCE**

A. Refer to specification 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."

E. Categorize selected refrigerant with ASHRAE 34-2022. Submit selected refrigerant for information.

**1.6 AS-BUILT DOCUMENTATION**

A. Comply with requirements in Paragraph “AS-BUILT DOCUMENTATION” in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

**PART 2 - PRODUCTS**

**2.1 PIPING AND FITTINGS**

A. Refrigerant Piping: 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. Coils shall be tagged ASTM B280 by the manufacturer.

B. Water and Drain Piping: Copper water tube, ASTM B88M, Type B or C (ASTM B88, Type M or L).

C. 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.
    b. Solder Joints, water and drain: 95-5 tin-antimony, ASTM B32 (95TA).
2. Refrigeration Valves:
    a. Stop Valves: Brass or bronze alloy, packless, or packed type with gas tight cap, frost proof, back seating.
    b. Pressure Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; UL listed. Forged brass with nonferrous, corrosion resistant internal working parts of high strength, cast iron bodies conforming to ASTM A126, Grade B. Set valves in accordance with ASHRAE Standard 15.
    c. Solenoid Valves: Comply with ARI 760 and UL 429, UL-listed, two-position, direct acting or pilot-operated, moisture and vapor-proof type of corrosion resisting materials, designed for intended service, and solder-end connections. Fitted with suitable NEMA 250 enclosure of type required by location and normally open holding coil.
    d. Thermostatic Expansion Valves: Comply with ARI 750. Brass body with stainless-steel or non-corrosive nonferrous internal parts, diaphragm and spring-loaded (direct-operated) type with sensing bulb and distributor having side connection for hot-gas bypass and external equalizer. Size and operating characteristics as recommended by manufacturer of evaporator and factory set for superheat requirements. Solder-end connections. Testing and rating in accordance with ASHRAE Standard 17.
    e. Electronic Thermostatic Expansion Valves: Electronic thermal expansion valves shall be stepper motor high resolution drive assembly type for precision control. Valve shall not exceed 6 watts max consumption. Compatibility tested with most HC, CFC, HCFC, and HFC refrigerants and oils. Valve pistons and ports to be characterized to provide improved flow resolution and performance. Valves to be interfaced with microprocessor-based controllers by devise manufacturer with temperature feedback loop. Electric expansion valves to be sized with nominal steps of stroke for tonnage application as recommended by valve manufacture ranging from 500 steps on small tonnage (under 5 tons per circuit) to 6300 on large tonnage circuits (over 100 tons per circuit)

f. Check Valves: Brass or bronze alloy with swing or lift type, with tight closing resilient seals for silent operation; designed for low pressure drop, and with solder-end connections. Direction of flow shall be legibly and permanently indicated on the valve body.

3. 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 greater 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.
4. Refrigerant Moisture/Liquid Indicators: Double-ported type having heavy sight glasses sealed into forged bronze body and incorporating means of indicating refrigerant charge and moisture indication. Provide screwed brass seal caps.
5. Refrigerant Filter-Dryers: UL listed, angle or in-line type, as shown in the contract documents. Conform to ARI Standard 730. Heavy gauge steel shell protected with corrosion-resistant paint; perforated baffle plates to prevent desiccant bypass. Size as recommended by manufacturer for service and capacity of system with connection not less than the line size in which installed. Filter driers with replaceable filters shall be furnished with one spare element of each type and size.
6. 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.
7. Oil Separators: Provide for condensing units, as shown. All welded steel construction with capacity to eliminate a minimum of 95 percent of the oil from the hot gas flowing through it. Provide manufacturer's published ratings for minimum and maximum refrigeration tonnage corresponding to this oil separating efficiency. Separator shall be equipped with a float valve to prevent return of the hot gas to crankcase, and shall have isolating stop valves so it can be opened and services without pumping out any other part of the system. ASME construction or UL listed.
8. Receivers: Conform to AHRI 495, steel construction, equipped with taps for liquid inlet and outlet valves, pressure relief valve and liquid level indicator.

**2.2 GAUGES**

A. Temperature Gauges: Comply with ASME B40.200. Industrial-duty type and in required temperature range for service in which installed. Gauges shall have Celsius scale in 1-degree

(Fahrenheit scale in 2-degree) graduations and with black number on a white face. The pointer shall be adjustable. Rigid stem type temperature gauges shall be provided in thermal wells located within 1525 mm (5 feet) of the finished floor. Universal adjustable angle type or remote element type temperature gauges shall be provided in thermal wells located 1525 to 2135 mm (5 to 7 feet) above the finished floor. Remote element type temperature gauges shall be provided in thermal wells located 2135 mm (7 feet) above the finished floor.

B. Vacuum and Pressure Gauges: Comply with ASME B40.100 and provide with throttling type needle valve or a pulsation dampener and shut-off valve. Gauge shall be a minimum of 90 mm (3-1/2 inches) in diameter with a range from 0 kPa (0 psig) to approximately 1.5 times the maximum system working pressure. Each gauge range shall be selected so that at normal operating pressure, the needle is within the middle-third of the range.
   1. Suction: 101 kPa (30 inches Hg) vacuum to 1723 kPa (gauge) (250 psig).
   2. Discharge: 0 to 3445 kPa (gauge) (0 to 500 psig).

**2.3 THERMOMETERS AND WELLS**

A. Refer to specification Section 23 21 13, HYDRONIC PIPING.

**2.4 PIPE SUPPORTS**

A. Refer to specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

**2.5 REFRIGERANTS AND OIL**

A. Provide EPA approved refrigerant and oil for proper system operation.

**2.6 PIPE/CONDUIT ROOF PENETRATION COVER**

A. Prefabricated Roof Curb: Galvanized steel or extruded aluminum 300 mm (12 inches) overall height, continuous welded corner seams, treated wood nailer,38 mm (1-1/2 inch) thick, 48 kg/cubic meter (3 pounds/cubic foot) density rigid mineral fiberboard insulation with metal liner, built-in cant strip (except for gypsum or tectum decks). For surface insulated roof deck, provide raised cant strip (recessed mounting flange) to start at the upper surface of the insulation. Curbs shall be constructed for pitched roof or ridge mounting as required to keep top of curb level.

B. Penetration Cover: Galvanized sheet metal with flanged removable top. Provide 38 mm (1-1/2 inch) thick mineral fiber board insulation.

C. Flashing Sleeves: Provide sheet metal sleeves for conduit and pipe penetrations of the penetration cover. Seal watertight penetrations.

**2.7 PIPE INSULATION FOR DX HVAC SYSTEMS**

A. Refer to specification Section 23 07 11, HVAC,

**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 in the contract documents.
   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 greater 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 specification Section 13 05 41, SEISMIC RESTRAINTS REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS, for bracing of piping in seismic areas.

G. 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.

**3.2 PIPE AND TUBING INSULATION**

A. Refer to specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

B. Apply two coats of weather-resistant finish as recommended by the manufacturer to insulation exposed to outdoor weather.

**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.

B. Systems containing greater than 50 kg (110 lb) of refrigerant shall be provided with durable signs, in accordance with ANSI A13.1 and ANSI Z535.1, having letters not less than 13 mm (1/2 inch) in height designating:

1. Valves and switches for controlling refrigerant flow, the ventilation and the refrigerant compressor(s).
2. Signs on all exposed high pressure and low pressure piping installed outside the machinery room, with name of the refrigerant and the letters "HP" or "LP."
3. Signage and labeling identifying “flammable” or “health hazard” based on chosen refrigerant per requirements and definitions in ASHRAE 34-2022.

**3.4 FIELD QUALITY CONTROL**

A. 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.

B. 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 gauges, 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.

C. Test Medium: A suitable dry gas such as nitrogen or 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 gauge 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. Ensure qualified workers are competent in the application of chosen refrigerant per ASHRAE 15 and ASHRAE 34. 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 psig) gauge. 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 gauge reading in mPa (microns). Pull the system down to 665 mPa (500 microns) 665 mPa (2245.6 inches of mercury at 60 degrees F) and hold for 8 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 STARTUP AND TESTING**

A. 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 of 7 days prior notice.

B. Provide services of manufacturer's technical representative for four hours to instruct VA personnel in operation and maintenance of computer room air conditioning equipment.

**3.7 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 CxA.

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.

**3.8 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 23 31 00**
**HVAC DUCTS AND CASINGS**

## PART 1 - GENERAL

### 1.1 DESCRIPTION

A. A complete listing of common acronyms and abbreviations are included in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

B. Ductwork and accessories for HVAC including the following:

1. Supply air, return air, outside air, exhaust, make-up air, and relief systems.

C. Definitions:

1. 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.
2. Duct Pressure Classification: SMACNA HVAC Duct Construction Standards, Metal and Flexible.
3. Exposed Duct: Exposed to view in a finished room

### 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 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.

D. Section 07 84 00, FIRESTOPPING.

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

E. Section 22 11 00, FACILITY WATER DISTRIBUTION.

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 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

K. Section 23 34 00, HVAC FANS.

L. Section 23 36 00, AIR TERMINAL UNITS.

M. Section 23 40 00, HVAC AIR CLEANING DEVICES.

N. Section 23 82 00, CONVECTION HEATING and COOLING UNITS.

O. Section 23 82 16, AIR COILS.

**1.3 APPLICABLE PUBLICATIONS**

***Note: From the date contract documents are provided, the Contractor shall use the most current published versions of all listed standards and references below.**

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 Civil Engineers (ASCE):

7 .....Minimum Design Loads for Associated Criteria for Buildings and Other Structures

C. American Society for Testing and Materials (ASTM):

A653/A653M.....Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

A1011/A1011 .....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

B209 .....Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate

C1071 .....Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)

E1 .....Standard Specification for ASTM Liquid-in-Glass Thermometers

E77 .....Standard Test Method for Inspection and Verification of Thermometers

E84 .....Standard Test Method for Surface Burning Characteristics of Building Materials

D. National Fire Protection Association (NFPA):

90A.....Standard for the Installation of Air-Conditioning and Ventilating Systems

96 .....Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations

E. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):

006 .....HVAC Duct Construction Standards, Metal and Flexible, 4th Edition

016 .....HVAC Air Duct Leakage Test Manual, 2nd Edition

.....Fibrous Glass Duct Construction Standards, 7th Edition

F. Underwriters Laboratories, Inc. (UL):

181 .....Standard for Factory-Made Air Ducts and Air Connectors

555 .....Standard for Fire Dampers

555S .....Standard for Smoke Dampers

G. Department of Veterans Affairs (VA):

PG-18-10 .....Physical Security Design Manual for VA Mission Critical Facilities

**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 XX XX, SECTION TITLE”, 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. Rectangular Ducts:
    a. Schedules of duct systems, materials and selected SMACNA construction alternatives for joints, sealing, gauge and reinforcement.
    b. Duct liner.
    c. Sealants and gaskets.
    d. Access doors.
2. Round and Flat Oval DuctS:
    a. Manufacturer's details for duct fittings.
    b. Sealants and gaskets.
    c. Access sections.
    d. Installation instructions.
3. Volume dampers, back draft dampers.
4. Upper hanger attachments.
5. Fire dampers, fire doors, and smoke dampers with installation instructions.
6. Sound attenuators, including pressure drop and acoustic performance.
7. Flexible ducts and clamps, with manufacturer's installation instructions.

8. Flexible connections.
9. Instrument test fittings.
10. Details and design analysis of alternate or optional duct systems.

D. Coordination Drawings: Refer to paragraph SUBMITTALS in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

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.

**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.

B. Refer to Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS for additional sustainable design requirements.

C. Fire Safety Code: Comply with NFPA 90A.

D. Duct System Construction and Installation: Referenced SMACNA Standards are the minimum acceptable quality.

E. 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 in the contract documents.

F. 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 he duct or provide at least the same level of corrosion resistance.

**1.6 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 DUCT MATERIALS AND SEALANTS**

A. General: Except for systems specified otherwise, construct ducts, casings, and accessories of galvanized sheet steel, ASTM A653/A653M, coating G90; or, aluminum sheet, ASTM B209, alloy 1100, 3003 or 5052.

B. Joint Sealing: Refer to SMACNA HVAC Duct Construction Standards, Metal and Flexible.

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 prohibited 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 the ductwork in accordance with the following pressure classifications:

B. Duct Pressure Classification:

1. 0 to 13 mm (0 to 1/2 inch)
2. 13 mm to 25 mm (1/2 inch to 1 inch)
3. 25 mm to 50 mm (1 inch to 2 inch)
4. 50 mm to 75 mm (2 inch to 3 inch)
5. 75 mm to 100 mm (3 inch to 4 inch)

C. Seal Class: All ductwork shall receive Class A Seal.

D. Round and Flat Oval Ducts: Furnish duct and fittings made by the same manufacturer to ensure 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 in the contract documents.

1. Elbows: Diameters 75 through 203 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, Metal and Flexible.
3. Ribbed Duct Option: Lighter gauge round/oval duct and fittings may be furnished provided certified tests indicating that the rigidity and performance is equivalent to SMACNA standard gauge ducts are submitted.
    a. Ducts: Manufacturer's published standard gauge, 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 Standards, Metal and Flexble. Because of high pressure loss, do not use internal tie-rod reinforcement unless approved by the COR.

E. Casings and Plenums: Construct in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible, including curbs, access doors, pipe penetrations, eliminators and drain pans. Access doors shall be hollow metal, insulated, with latches and door pulls, 508 mm (20 inches) wide by 1219 to 1372 mm (48 to 54 inches) high. Provide view port in the doors where shown. Provide drain for outside air louver plenum. Outside air plenum shall have exterior insulation. Drain piping shall be routed to the nearest floor drain.

F. Volume Dampers: Single blade or opposed blade, multi-louver type as detailed in SMACNA Standards. Refer to SMACNA for Single Blade and Multi-blade Volume Dampers.

G. Duct Hangers and Supports: Refer to SMACNA Standards. Avoid use of trapeze hangers for round duct.

**2.3 DUCT LINER (WHERE INDICATED IN THE CONTRACT DOCUMENTS)**

A. Duct sizes shown in the contract documents for lined duct are clear opening inside lining.

B. Duct liner is only permitted to be used for return, relief and general exhaust ducts. Duct liner is prohibited for outside air ducts, supply air ducts or any other positive pressure ductwork (provide exterior insulation only).

C. Rectangular Duct or Casing Liner: ASTM C1071, Type I (flexible), or Type II (board), 25 mm (1 inch) minimum thickness, applied with mechanical fasteners and 100 percent coverage of adhesive in conformance with SMACNA.

**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 duct mounted coil and humidifier.
   2. Each fire damper (for link service), smoke damper and automatic control damper.
   3. Each duct mounted smoke detector.
   4. For cleaning operating room supply air duct and kitchen hood exhaust duct, locate access doors at 6.1 m (20 feet) intervals and at each change in duct direction.

B. Openings shall be as large as feasible in small ducts, 305 mm by 305 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, Metal and Flexible.
   2. For Round and Flat Oval Ducts: Refer to SMACNA HVAC Duct Construction Standards, Metal and Flexible.

**2.5 FIRE DAMPERS**

A. Galvanized steel, interlocking blade type, UL listing and label, 1-1/2-hour rating, 70 degrees C (158 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 gauge), 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): 457 m/min (1500 fpm). Maximum static pressure loss: 32 Pa (0.13 inch WG).

B. Leakage: Class I.

C. Maximum Air Leakage, Closed Damper: 0.32 cubic meters /min/square meter (4.0 cfm per square foot) at 750 Pa (3 inch WG) differential pressure.

D. Minimum Requirements for Dampers:

1. Shall comply with requirements 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, 305 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 contract documents for required control operation.

E. 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 BLAST DAMPERS**

A. Frame: Damper frame shall be one piece construction. 12 inches (305 mm) deep by 2 inches (52 mm) flanged by 10 ga. (2 mm) thick. Sleeve or channel with inner frame is not acceptable. Refer to drawings for square to round transitions required.

B. Blades: The damper blades shall be airfoil shaped double skin. Minimum 14 ga. (2 mm) skin. Blade orientation is horizontal (standard).

C. Bearings: 2-bolt, flange, relubricable ball bearings bolted to the frame (Standard).

D. Linkage: Damper blade linkage shall be minimum 3/16 inch thick by 3/4 inch (5 mm by 19 mm) bar located on side of damper out of air stream. Pivot pins in linkage shall be stainless steel.

Bronze pins or bushings are not acceptable. Linkage shall include externally mounted release springs and adjustable tension to keep damper open until blast of specified pressure force blades closed.

E. Performance Data:
   1. Dampers in the vertical position shall be anchored to the supporting jamb elements and designed for a linear ramp-down load of 13.5 psi for a duration of 7.6 ms (equating to an impulse of 51 psi*ms).
   2. Dampers mounted in a horizontal duct shall be anchored to the supporting jamb elements and designed for a linear ramp-down load of 6.2 psi for a duration of 8.0 ms (equating to an impulse of 24.8 psi*ms).
   3. Dampers shall remain operable during and after experiencing design level pressures. Deformation not to exceed that defined by a Superficial response equating to a ductility < 1.

**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 greater than 203 mm (8 inches) in diameter shall be Class 1. Ducts less than 203 mm (8 inches) in diameter shall be Class 1 or Class 2.

C. Insulated Flexible Air Duct: Factory-fabricated 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 152 mm (6 inch) duct, of 762 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: 1219 m/min (4000 fpm).
   3. Minimum Working Pressure, Inches of Water Gauge: 2500 Pa (10 inches WG) positive, 500 Pa (2 inches WG) negative.

E. Duct Clamps: 100 percent nylon strap, 80 kg (176 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.

F. Flexible air duct is prohibited in operating room suites, SPS processing spaces, Pharmacy compounding spaces, Protective Environment spaces, Isolation Rooms, Clean Rooms, Bio-containment Laboratories, Research Laboratories, and Clinical Laboratories.

**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 ounces) neoprene coated fiberglass fabric approximately 152 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 PREFABRICATED ROOF CURBS**

A. Galvanized steel or extruded aluminum 305 mm (12 inches) above finish roof service, continuous welded corner seams, treated wood nailer, 38 mm (1-1/2 inch) thick, 48 kg/cubic meter (3 pound/cubic feet) density rigid mineral fiberboard insulation with metal liner, built-in cant strip (except for gypsum or tectum decks). For surface insulated roof deck, provide raised cant strip (recessed mounting flange) to start at the upper surface of the insulation. Curbs shall be constructed for pitched roof or ridge mounting as required to keep top of curb level.

**2.11 FIRESTOPPING MATERIAL**

A. Refer to Section 07 84 00, FIRESTOPPING.

**2.12 DUCT MOUNTED THERMOMETER (AIR)**

A. Stem Type Thermometers: ASTM E1, 7 inch scale, red appearing mercury, lens front tube, cast aluminum case with enamel finish and clear glass or polycarbonate window, brass stem, 2 percent of scale accuracy to ASTM E77 scale calibrated in degrees Fahrenheit.

B. Thermometer Supports:

1. Socket: Brass separable sockets for thermometer stems with or without extensions as required, and with cap and chain.

2. Flange: 75 mm (3 inch) outside diameter reversible flange, designed to fasten to sheet metal air ducts, with brass perforated stem.

**2.13 DUCT MOUNTED TEMPERATURE SENSOR (AIR)**

A. Refer to Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

**2.14 INSTRUMENT TEST FITTINGS**

A. Manufactured type with a minimum 50 mm (2 inch) length for insulated duct, and a minimum 25 mm (1 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. If an installation is unsatisfactory to the COR, the contractor shall correct the installation at no additional cost or time to the Government.

B. Comply with provisions of Section 23 05 11, COMMON WORK RESULTS FOR HVAC, particularly regarding coordination with other trades and work in existing buildings.

C. Fabricate and install ductwork and accessories in accordance with referenced SMACNA Standards:

1. Contract documents 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 in the contract documents 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.

D. Install duct hangers and supports in accordance with SMACNA Standards.

E. Install fire dampers and smoke dampers in accordance with the manufacturer's instructions to conform to the installation used for the rating test. Install fire dampers and 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 resetting of fire dampers and operation of smoke dampers to the COR.

F. Seal openings around duct penetrations of floors and fire rated partitions with fire stop material as required by NFPA 90A.

G. Flexible Duct Installation: Refer to SMACNA Standards. Ducts shall be continuous, single pieces not over 1.5 m (5 feet) long per NFPA 90A, as straight and short as feasible, 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. Flexible ducts shall not penetrate floors, or any chase or partition designated as a fire or smoke barrier, including corridor partitions fire rated one hour or two hours. Support ducts SMACNA Standards.

H. 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.

I. 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.

J. Air Flow Measuring Devices: Install units with minimum straight run distances, upstream and downstream as recommended by the manufacturer.

K. Low Pressure Duct Liner: Install in accordance with SMACNA Standards.

L. 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 and relief ductwork), section by section, including fans, coils and filter sections.

C. Test procedure, apparatus and report shall conform to SMACNA HVAC Air Duck 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.

**3.4 TESTING, ADJUSTING, AND BALANCING (TAB)**

A. Refer to Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC.

**3.5 OPERATING AND PERFORMANCE TESTS**

A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

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**SECTION 23 34 00**
**HVAC FANS**

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

A. A complete listing of common acronyms and abbreviations are included in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

B. Fans for heating, ventilating and air conditioning.

C. Product Definitions: AMCA 99

**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 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.

D. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

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 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 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC.

I. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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

K. Section 23 82 16, AIR COILS.

L. Section 26 29 11, MOTOR CONTROLLERS.

**1.3 APPLICABLE PUBLICATIONS**

***Note: From the date contract documents are provided, the Contractor shall use the most current published versions of all listed standards and references below.**

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. Air Movement and Control Association International, Inc. (AMCA):

99- .....Standards Handbook

210 .....Laboratory Methods of Testing Fans for Aerodynamic Performance Rating

300 .....Reverberant Room Method for Sound Testing of Fans

C. Underwriters Laboratories, Inc. (UL):

181 .....Standard for Factory-Made Air Ducts and Air Connectors

**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 XX XX, SECTION TITLE”, with applicable paragraph identification.

C. Manufacturers 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. Plenum fan, motors, and drives.
2. Centrifugal fans, motors, drives, accessories, and coatings.
    a. Inline centrifugal fans.
    b. Tubular Centrifugal Fans.

D. Certified sound power levels for each fan.

E. Motor ratings, types, electrical characteristics, and accessories.

F. Certified fan performance curves for each fan showing cubic feet per minute (CFM) versus static pressure, efficiency, and horsepower for design point of operation.

G. 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.

H. 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 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 QUALITY ASSURANCE**

A. Fans and power ventilators shall bear the AMCA performance seal.

B. Operating Limits for Centrifugal Fans: AMCA 99 (Class I, II, and III).

C. Fans and power ventilators shall comply with the following standards:

1. Testing and Rating: AMCA 210.

2. Sound Rating: AMCA 300.

D. 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.

E. Safety Criteria: Provide manufacturer's standard screen on fan inlet and discharge where exposed to operating and maintenance personnel.

F. 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. Manufacturer’s paint and paint system shall meet the minimum requirements of ASTM D1735 water fog, ASTM B117 salt spray, ASTM D3359 adhesion, and ASTM G152 and ASTM G153 for carbon arc light apparatus for exposure of non-metallic material.

G. 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.

H. Refer to Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS for additional sustainable design requirements.

**1.6 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 PLENUM FAN**

A. Plenum Fans – Single and/or Multiple Fans in an Array:

1. General: Fans shall be Class II (minimum) construction with single inlet, aluminum wheel and stamped air-foil aluminum bladed. The fan wheel shall be mounted on the directly-driven motor shaft in AMCA Arrangement 4. Fans shall be dynamically balanced and internally isolated to minimize the vibrations. Provide a steel inlet cone for each wheel to match with the fan inlet. Locate fan in the air stream to assure proper flow. The fan performance shall be rated in accordance with AMCA 210 or ASHRAE 51.
2. Allowable vibration tolerances for fan shall not exceed a self-excited vibration maximum velocity of 0.005 m/s (0.20 inch per second) RMS, filter in, when measured with a vibration meter on bearing caps of machine in vertical, horizontal and axial directions or measured at equipment mounting feet if bearings are concealed. After field installation, compliance to this requirement shall be demonstrated with field test in accordance with Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT and Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC. Following fan assembly, the complete fan assembly balance shall be tested using an electronic balance analyzer with a tunable filter and stroboscope. Vibration measurements shall be taken on each motor bearing housing in the vertical, horizontal, and axial planes (5 total measurements, 2 each motor bearing and 1 axial).
3. The plenum fans shall be driven by variable speed drives with at least one back-up drive as shown in the design documents. Use of a drive with bypass is not permitted.
4. Multiple fans shall be installed in a pre-engineered structural frame to facilitate fan stacking. All fans shall modulate in unison, above or below the synchronous speed within the limits specified by the manufacturer, by a common control sequence. Staging of the fans is not permitted. Redundancy requirement shall be met by all operating fans in an array and without the provision of an idle standby fan.
5. Fan Accessories
    a. Fan Isolation: Provide an actuator-controlled damper an automatic back draft damper to isolate the fan not in operation due to failure.
    b. Fan Airflow Measurement: Provide an airflow measuring device integral to the fan to measure air volume within +/- 5 percent accuracy. The probing device shall not be placed in the airflow path to stay clear of turbulence and avoid loss of performance.

**2.2 CENTRIFUGAL FANS**

A. 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 13 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. Furnish variable speed fan motor controllers where shown in the contract documents. Refer to Section 26 29 11, MOTOR CONTROLLERS. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC for controller/motor combination requirements.

C. Inline Centrifugal Fans: 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.

D. Tubular Centrifugal Fans: Provide hot rolled steel, one-piece design housing incorporating integral guide vanes, motor mounts, bolted access hatch and end flanges. Provide spun inlet bell and screen for unducted inlet and screen for unducted outlet. Provide welded steel, flanged inlet and outlet cones for ducted connection. Provide mounting legs or suspension brackets as required for support. Guide vanes shall straighten the discharge air pattern to provide linear flow.

**PART 3 - EXECUTION**

**3.1 INSTALLATION**

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. Install fan, motor and drive in accordance with manufacturer's instructions.

C. Install vibration control devices as shown in the contract documents and specified in Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.

**3.2 STARTUP AND TESTING**

A. Verify operation of motor, drive system and fan wheel according to the contract documents.

B. 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.

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. Provide a minimum notice of 10 working days prior to startup and testing.

**3.3 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.

**3.4 DEMONSTRATION AND TRAINING**

A. Provide services of manufacturer’s technical representative for 10 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 37 00**
**AIR OUTLETS AND INLETS**

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

A. A complete listing of common acronyms and abbreviations are included in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

B. Air Outlets and Inlets: Diffusers, registers, and grilles.

**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 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.

D. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

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.

**1.3 APPLICABLE PUBLICATIONS**

***Note: From the date contract documents are provided, the Contractor shall use the most current published versions of all listed standards and references below.**

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. Air Duct Council:
Flexible Duct Performance & Installation Standards (Manual), 5th Edition Green Book

C. American Society for Testing and Materials (ASTM):
B209/B209M .....Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate

**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 37 00, Air Outlets and Inlets”, 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. Air intake/exhaust hoods.
2. Diffusers, registers, grilles, and accessories.

D. 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.

**1.5 QUALITY ASSURANCE**

A. Fire Safety Code: Comply with NFPA 90A.

B. 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.

C. Refer to Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS for additional sustainable design requirements.

**1.6 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 GRAVITY INTAKE/EXHAUST VENTILATORS (ROOF MOUNTED)**

A. Aluminum, ASTM B209/B209M, louvered, spun, or fabricated using panel sections with roll-formed edges, 13 mm (1/2 inch) mesh aluminum welded wire bird screen, with gravity or motorized dampers where shown, accessible interior, designed for wind velocity specified in paragraph Intake/Exhaust Hoods Exposed to Wind Velocity in this section.
1. Spun Intake/Exhaust Ventilators: Spun aluminum structural components shall be constructed of minimum 1.6 mm (16 Gauge) marine alloy aluminum, bolted to a rigid aluminum support structure. The aluminum base shall have continuously welded curb cap corners for maximum leak protection. The spun aluminum baffle shall have a rolled bead for added strength.

2. Louvered Intake/Exhaust Hoods: Louvered hood constructed from 0.081 mm (0.003 inch) extruded aluminum tiers welded to a minimum 4.3 mm (8 Gauge) aluminum support structure. The aluminum hood shall be constructed of a minimum 0.064 mm (0.025 inch) marine alloy aluminum and provided with a layer of anti-condensate coating. The aluminum base shall have continuously welded curb cap corners for maximum leak protection.
3. Low Silhouette Intake/Exhaust Ventilator: The unit shall be of bolted and welded construction utilizing corrosion resistant fasteners. The aluminum hood shall be constructed of minimum 1.9 mm (14 Gauge) marine alloy aluminum, bolted to a minimum 4.3 mm (8 Gauge) aluminum support structure. The aluminum base shall have continuously welded curb cap corners for maximum leak protection. Birdscreen constructed of 13 mm (1/2 inch) mesh shall be mounted across the relief opening.

B. See ventilator schedule on the contract drawings. Sizes shown on the contract drawings designate throat size. Area of ventilator perimeter opening shall be not less than the throat area.

C. Provide roof curb by unit manufacturer. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC for additional requirements.

**2.2 EQUIPMENT SUPPORTS**

Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

**2.3 AIR OUTLETS AND INLETS**

A. Materials:
1. Steel or aluminum
2. Exposed Fastenings: The same material as the respective inlet or outlet. Fasteners for aluminum may be stainless-steel.
3. Contractor shall review all ceiling drawings and details and provide all ceiling mounted devices with appropriate dimensions and trim for the specific locations.

B. Performance Test Data: In accordance with Air Duct Council “Flexible Duct Performance & Installation Standards (Manual), Green Book”. Refer to Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT for NC criteria.

C. Air Supply Outlets:
1. Supply Grilles: Double deflection type with horizontal face.
a. Margin: Flat, 32 mm (1-1/4 inches) wide.
b. Bar Spacing: 19 mm (3/4 inch) maximum.

c. Finish: Off white baked enamel for ceiling mounted units

D. Return and Exhaust Registers and Grilles.

1. Finish: Off-white baked enamel for ceiling mounted units. Wall units shall have a prime coat for field painting or shall be extruded aluminum with manufacturer's standard aluminum finish.

**PART 3 - EXECUTION**

**3.1 INSTALLATION**

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. Comply with provisions of Section 23 05 11, COMMON WORK RESULTS FOR HVAC, particularly regarding coordination with other trades and work in existing buildings.

C. 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.

**3.2 INTAKE AND EXHAUST HOODS EXPOSED TO WIND VELOCITY**

A. Provide additional support and bracing to all exposed roof hoods installed on the roof or outside the building to withstand wind velocity of 145 km/h (90 mph)

**3.3 TESTING, ADJUSTING, AND BALANCING (TAB)**

A. Refer to Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC.

**3.4 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.

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**SECTION 23 40 00**
**HVAC AIR CLEANING DEVICES**

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

A. A complete listing of common acronyms and abbreviations are included in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

B. Air filters for heating, ventilating and air conditioning.

C. Definitions: Refer to ASHRAE 52.2 for definitions of face velocity, net effective filtering area, media velocity, initial resistance (pressure drop), MERV (Minimum Efficiency Reporting Value), PSE (Particle Size Efficiency), particle size ranges for each MERV number, dust holding capacity and explanation of electrostatic media-based filtration products versus mechanical filtration products. Refer to ASHRAE 52.2 for definition of MERV-A.

**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 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.

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 37 00, AIR OUTLETS AND INLETS.

G. Section 23 73 00, INDOOR CENTRAL-STATION AIR-HANDLING UNITS

**1.3 APPLICABLE PUBLICATIONS**

***Note: From the date contract documents are provided, the Contractor shall use the most current published versions of all listed standards and references below.**

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. Where conflicts occur these specifications and the VHA standards will govern.

B. Air-Conditioning, Heating, and Refrigeration Institute (AHRI):

850 .....Performance Rating of Commercial and Industrial Air Filter Equipment

C. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE):

52.2.....Method of Testing General Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size

170 .....Ventilation of Health Care Facilities

D. American Society of Mechanical Engineers (ASME):

ASME Boiler and Pressure Vessel Code -

BPVC Section IX.....Welding, Brazing, and Fusing Qualifications

E. American Welding Society (AWS):

D9.1/D9.1M .....Sheet Metal Welding Code

F. International Organization for Standardization (ISO):

9001 .....Quality Management Systems - Requirements

G. Underwriters Laboratories, Inc. (UL):

586 .....Standard for High-Efficiency, Particulate, Air Filter Units

900 .....Standard for Air Filter Units

**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 40 00, HVAC AIR CLEANING DEVICES”, 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. Extended surface filters.
2. Holding frames. Identify locations.
3. Side access housings. Identify locations, verify insulated doors.
4. HEPA filters.
5. Magnehelic gauges.

D. Air Filter performance reports.

E. Suppliers warranty.

F. 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.

**1.5 QUALITY ASSURANCE**

A. Air Filter Performance Report for Extended Surface Filters:

1. Submit a test report for each Grade of filter being offered. The report shall not be more than three (3) years old and prepared by using test equipment, method and duct section as specified by ASHRAE 52.2 for type filter under test and acceptable to COR, indicating that filters comply with the requirements of this specification. Filters utilizing partial or complete synthetic media will be tested in compliance with pre-conditioning steps as stated in ASHRAE 52.2. All testing is to be conducted on filters with a nominal 24 inch by 24 inch face dimension. Test for 500 fpm will be accepted for lower velocity rated filters provided the test report of an independent testing laboratory complies with all the requirements of this specification.
2. Government Option: The Government at its option may take one of the filters for each different type submitted and run an independent test to determine if the filter meets the requirements of this specification. When the filter meets the requirements, the Government will pay for the test. When the filter does not meet the specification requirements, the manufacturer will be required to pay for the test and replace the filters with filters that will perform as required by the specifications.
3. Guarantee Performance: The manufacturer shall supply ASHRAE 52.2 test reports on each filter type submitted. Any filter supplied will be required to maintain the minimum efficiency shown on the ASHRAE 52.2 report throughout the time the filter is in service. Within the first 6 to 12 weeks of service a filter may be pulled out of service and sent to an independent laboratory for ASHRAE 52.2 testing for initial efficiency only. If this filter fails to meet the minimum level of efficiency shown in the previously submitted reports, the filter manufacturer/distributor shall take back all filters and refund the owner all monies paid for the filters, cost of installation, cost of freight and cost of testing.

B. Filter Warranty for Extended Surface Filters: Guarantee the filters against leakage, blow-outs, and other deficiencies during their normal useful life, up to the time that the filter reaches the final pressure drop. Defective filters shall be replaced at no additional cost or time to the Government.

C. Comply with UL 900 for flame test.

D. Nameplates: Each filter shall bear a label or name plate indicating manufacturer's name, filter size and rated efficiency.

E. 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.

F. Refer to Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS for additional sustainable design requirements.

**1.6 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 REPLACEMENT FILTER ELEMENTS TO BE FURNISHED**

A. To allow temporary use of HVAC systems for testing and in accordance with Paragraph, TEMPORARY USE OF MECHANICAL AND ELECTRICAL SYSTEMS in Section 01 00 00, GENERAL REQUIREMENTS. Provide one complete set of additional filters to the COR.

B. The COR will direct whether these additional filters will either be installed as replacements for dirty units or turned over to VA for future use as replacements.

**2.2 EXTENDED SURFACE AIR FILTERS**

A. Use factory assembled air filters of the extended surface type with supported or non-supported cartridges for removal of particulate matter in air conditioning, heating and ventilating systems. Filter units shall be of the extended surface type fabricated for disposal when the contaminant load limit is reached as indicated by maximum (final) pressure drop.

B. Filter Classification: UL listed and approved conforming to UL 900.

C. HVAC Filter Types:

| HVAC Filter Types | | | | |
|---|---|---|---|---|
| MERV Value ASHRAE 52.2 | | Application | Particle Size | Thickness /Type |
| 8 | | Pre-Filter | 3 to 10 Microns | 50 mm (2 inch) Throwaway |
| 11 | | After-Filter | 1 to 3 Microns | 152 mm (6 inch) or 305 mm (12 inch) Rigid Cartridge |
| 13 | | (Alternate) | 0.3 to 1 Microns | 152 mm (6 inch) or |

| | | | | |
|---|---|---|---|---|
| | | After-Filter | | 305 mm (12 inch) Rigid Cartridge |
| 14 | | After-Filter | 0.3 to 1 Microns | 152 mm (6 inch) or 305 mm (12 inch) Rigid Cartridge |

D. HEPA Filters:

| HEPA Filters | | | | |
|---|---|---|---|---|
| Efficiency at 0.3 Micron | Application | Initial Resistance (inches WG) | Rated cfm | Construction |
| 99.97 | Final Filter | 1.35 | 1100 | Galvanized Frame X-Body |
| 99.97 | Final Filter | 1.00 | 2000 | Aluminum Frame V-Bank |

**2.3 MEDIUM EFFICIENCY PLEATED PANEL PRE-FILTERS (50 MM (2 INCH); MERV 8; UL 900 CLASS 2)**

A. Construction: Air filters shall be medium efficiency ASHRAE pleated panels consisting of cotton and synthetic or 100 percent virgin synthetic media, self-supporting media with required media stabilizers, and beverage board enclosing frame. Filter media shall be lofted to a uniform depth and formed into a uniform radial pleat. The media stabilizers shall be bonded to the downstream side of the media to maintain radial pleats and prevent media oscillation. An enclosing frame of no less than 28-point high wet-strength beverage board shall provide a rigid and durable enclosure. The frame shall be bonded to the media on all sides to prevent air bypass. Integral diagonal support members on the air entering and air exiting side shall be bonded to the apex of each pleat to maintain uniform pleat spacing in varying airflows.

B. Performance: The filter shall have a Minimum Efficiency Reporting Value of MERV 8 when evaluated under the guidelines of ASHRAE 52.2. The media shall maintain or increase in efficiency over the life of the filter. All testing is to be conducted on filters with a nominal 610 mm by 610 mm (24 inch by 24 inch) face dimension.

| | |
|---|---|
| Minimum Efficiency Reporting (MERV) | 8 |
| Dust Holding Capacity (Grams) | 105 |
| Nominal Size (Inches Width x Height x Depth) | 24x24x2 |
| Rated Air Flow Capacity (cfm) | 2,000 |
| Rated Air Flow Rate (fpm) | 500 |
| Final Resistance (Inches WG)<br>Maximum Recommended Change-Out Resistance (Inches WG) | 1.0<br>0.66 |

| | |
|---|---|
| Rated Initial Resistance (Inches WG) | 0.33 |

C. The filters shall be approved and listed by Underwriters Laboratories, Inc. as Class 2 when tested according to UL 900.

**2.4 HIGH EFFICIENCY EXTENDED SURFACE (INTERMEDIATE/AFTER (FINAL)) CARTRIDGE FILTERS (305 MM (12 INCH); MERV 14/13/11; UL 900 CLASS 2)**

A. Construction: Air filters shall consist of 8 pleated media packs assembled into 4 V-banks within a totally plastic frame. The filters shall be capable of operating at temperatures up to 176 degrees F. The filters shall either fit without modification or be adaptable to the existing holding frames. The molded end panels are to be made of high impact polystyrene plastic. The center support members shall be made of ABS plastic. No metal components are to be used.

B. Media: The media shall be made of micro glass fibers with a water repellent binder. The media shall be a dual density construction, with coarser fibers on the air entering side and finer fibers on the air leaving side. The media shall be pleated using separators made of continuous beads of low profile thermoplastic material. The media packs shall be bonded to the structural support members at all points of contact, this improves the rigidity as well as eliminates potential air bypass in the filter.

C. Performance: Filters of the size, air flow capacity and nominal efficiency (MERV) shall meet the following rated performance specifications based on the ASHRAE 52.2 test method. All testing is to be conducted on filters with a nominal 24 inch by 24 inch header dimension.

| Minimum Efficiency Reporting Value (MERV) | 14 | 13 | 11 |
|---|---|---|---|
| Gross Media Area (sf) | 197 | 197 | 197 |
| Dust Holding Capacity (Grams) | 486 | 430 | 465 |
| Nominal Size (Inches Width x Height x Depth) | 24x24x12 | 24x24x12 | 24x24x12 |
| Rated Air Flow Capacity (cfm) | 2,000 | 2,000 | 2,000 |
| Rated Air Flow Rate (fpm) | 500 | 500 | 500 |
| Final Resistance (Inches WG) | 2.0 | 2.0 | 2.0 |
| Maximum Recommended Change-Out Resistance (Inches WG) | 0.74 | 0.68 | 0.54 |
| Rated Initial Resistance (Inches WG) | 0.37 | 0.34 | 0.27 |

**2.5 HIGH EFFICIENCY PARTICULATE AIR (HEPA) FILTERS STANDARD CAPACITY (FINAL FILTER APPLICATION)**

A. Air filters shall be HEPA grade standard capacity air filters with waterproof micro glass fiber media, corrugated aluminum separators, urethane sealant, 16 gauge steel enclosing frame and fluid sealing gasket. Sizes shall be as noted on enclosed drawings or other supporting materials.

B. Construction: Filter media shall be one continuous pleating of microfine glass fiber media. Pleats shall be uniformly separated by corrugated aluminum separators incorporating a hemmed edge to prevent damage to the media. The media pack shall be potted into the enclosing frame with a fire-retardant urethane sealant. The enclosing frame shall be of 16 gauge steel, with a zinc aluminum alloy finish, and shall be bonded to the media pack to form a rugged and durable enclosure. The filter shall be assembled without the use of fasteners to ensure no frame penetrations. Overall dimensional tolerance shall be correct within -1/8 inch, +0 inch, and square within 1/8 inch. A poured-in-place seamless sealing gasket shall be included on the downstream side of the enclosing frame to form a positive seal upon installation.

C. Performance: The filter shall have a tested efficiency of 99.97 percent when evaluated according to IEST Recommended Practice. Initial resistance to airflow shall not exceed 1 inch WG at rated capacity. Filter shall be listed by Underwriters Laboratories as UL 900. The filter shall be capable of withstanding 10 inches WG without failure of the media pack. Manufacturer shall provide evidence of facility certification to ISO 9001.

| HEPA Performance (Standard Capacity) | | |
|---|---|---|
| Nominal Size (Inches Height x Width x Depth) | Airflow Capacity (cfm) | Media Area (sf) |
| 24x24x12 | 1080 at 1 Inch WG | 153 |
| 24x12x12 | 500 at 1 Inch WG | 33 |
| Follow manufacturer’s recommendation for change out resistance, typically double the initial. | | |

D. Supporting Data: The filter shall be labeled as to tested efficiency, rated/tested cfm, pressure drop and shall be serialized for identification. The manufacturer shall supply a Certificate of Conformance for each HEPA filter supplied to the facility.

**2.7 FILTER HOUSINGS/SUPPORT FRAMES**

A. Side Servicing Housings (HVAC Grade):

1. Filter housing shall be two-stage filter system consisting of 16 gauge galvanized steel enclosure, aluminum filter mounting track, universal filter holding frame, insulated dual-

access doors, static pressure tap, filter gaskets and seals. Inline housing depth shall not exceed 21 inches. Sizes shall be as noted on enclosed drawings or other supporting materials.

2. Construction: The housing shall be constructed of 16 gauge galvanized steel with pre-drilled standing flanges to facilitate attachment to other system components. Corner posts of Z-channel construction shall ensure dimensional adherence. The housing shall incorporate the capability of two stages of filtration without modification to the housing. A filter track, of aluminum construction shall be an integral component of housing construction. The track shall accommodate a 2 inch deep prefilter, a 6 inch or 12 inch deep rigid final filter, or a pocket filter with header. Insulated dual access doors, swing-open type, shall include high-memory sponge neoprene gasket to facilitate a door-to-filter seal. Each door shall be equipped with adjustable and replaceable positive sealing UV-resistant star-style knobs and replaceable door hinges. A universal holding frame constructed of 18 gauge galvanized steel, equipped with centering dimples, multiple fastener lances, and polyurethane filter sealing gasket, shall be included to facilitate installation of high-efficiency filters. The housing shall include a pneumatic pressure fitting to allow the installation of a static pressure gauge to evaluate pressure drop across a single filter or any combination of installed filters.
3. Performance: Leakage at rated airflow, upstream to downstream of filter, holding frame, and slide mechanism shall be less than 1 percent at 3 inches WG. Leakage in to or out of the housing shall be less than one half of 1 percent at 3 inches WG. Accuracy of pneumatic pressure fitting, when to evaluate a single-stage, or multiple filter stages, shall be accurate within ± 3 percent at 0.6 inch WG.
4. Manufacturer shall provide evidence of facility certification to ISO 9001.

B. Side-Access Housing (HEPA Grade):

1. Filter housing shall be two-stage filter system consisting of 14 gauge galvanized steel enclosure, spring-loaded crank-type sealing assembly for gasket seal type final filters, insulated dual-access doors with gasketing and positive sealing doorknobs. Inline housing depth shall not exceed 25 inches. Sizes shall be as noted on enclosed drawings or other supporting materials.
2. Construction: The housing shall be constructed of 14 gauge galvanized steel with mating flanges to facilitate attachment to other system components. All pressure boundaries shall be of all welded construction. The housing shall be weatherproof and suitable for

rooftop/outdoor installation. A prefilter track to accommodate nominal 2 inch deep prefilters, shall be an integral component of the housing. The housing shall incorporate a spring-loaded crank-type final filter sealing mechanism. The mechanism shall be geared to exert 700 pounds of pressure against each filter. The clamping frame shall have a continuous flat surface seal to compress all four downstream gasketed surfaces of the downstream seal filter. The final filter locking mechanism shall include a 3/4 inch socket adapter to facilitate opening or closing the mechanism. Insulated dual access doors shall include high-memory sponge neoprene gasket to facilitate a door-to-filter seal. Each door shall be equipped with adjustable and replaceable UV-resistant positive sealing knobs. The access doors shall be both hinged for swing open operation or designed to be completely removable. The housing shall include static pressure ports 1/8 inch NPT male to facilitate pressure drop measurements across prefilter, final filter, or combination thereof.

3. Performance: Manufacturer shall provide evidence of facility certification to ISO 9001.

C. Equipment Identification: Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

**2.8 INSTRUMENTATION**

A. Magnehelic Differential Pressure Filter Gauges: Nominal 4 inch diameter, 0 to 2 inches WG, 3 inch for HEPA range. Gauges shall be flush-mounted in aluminum panel board, complete with static tips, copper or aluminum tubing, and accessory items to provide zero adjustment.

B. DDC Static (Differential) Air Pressure Measuring Station: Refer to Section 23 09 23, DIRECT DIGITAL CONTROL SYSTEM FOR HVAC.

C. Provide one DDC sensor across each extended surface filter. Provide Petcocks for each gauge or sensor.

D. Provide one common filter gauge for two-stage filter banks with isolation valves to allow differential pressure measurement.

**2.9 HVAC EQUIPMENT FACTORY FILTERS**

A. Manufacturer standard filters within fabricated packaged equipment should be specified with the equipment and should adhere to industry standard.

B. Cleanable filters are prohibited.

C. Automatic roll type filters are prohibited.

**2.10 FILTER RETURN GRILLES**

A. Refer to Section 23 37 00, AIR OUTLETS AND INLETS.

**PART 3 – EXECUTION**

**3.1 INSTALLATION**

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. Install supports, filters, and gauges in accordance with manufacturer's instructions.

C. Label clearly with words "Contaminated Air" on exhaust ducts leading to the HEPA filter housing.

**3.2 STARTUP AND TESTING**

A. Clean and vacuum air handling units and plenums prior to starting air handling systems.

B. Replace pre-filters and install clean filter units prior to final inspection as directed by the COR.

C. 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.

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

E. 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.

- - E N D - - -

**SECTION 23 72 00**
**AIR-TO-AIR ENERGY RECOVERY EQUIPMENT**

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

A. A complete listing of common acronyms and abbreviations are included in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

B. This section specifies air-to-air plate heat exchangers.

**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 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.

D. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

E. 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 12, GENERAL MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.

G. Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC.

H. Section 23 07 11, HVAC INSULATION.

I. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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

K. Section 23 21 13, HYDRONIC PIPING.

M. Section 23 21 23, HYDRONIC PUMPS.

L. Section 23 31 00, HVAC DUCTS and CASINGS.

M. Section 23 40 00, HVAC AIR CLEANING DEVICES.

P. Section 23 82 16, AIR COILS.

**1.3 APPLICABLE PUBLICATIONS**

***Note: From the date contract documents are provided, the Contractor shall use the most current published versions of all listed standards and references below.**

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. Air Conditioning, Heating, and Refrigeration Institute (AHRI):

1060 ..... Performance Rating of Air-to-Air Heat Exchangers for Energy Recovery Ventilation Equipment

C. American Society of Civil Engineers (ASCE):

7 .....Minimum Design Loads for Associated Criteria for Buildings and Other Structures

D. American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE):

15&34.....Safety Standard for Refrigeration Systems and Designation and Classification of Refrigerants (ANSI)

52.2 .....Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size

62.1 .....Ventilation for Acceptable Indoor Air Quality

84 .....Method of Testing Air-to-Air Heat/Energy Exchangers

E. American Society for Testing and materials (ASTM):

D635.....Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position

E84 .....Standard Test Method for Surface Burning Characteristics of Building Materials

F. Underwriters Laboratories, Inc (UL):

1812 .....Standard for Ducted Heat Recovery Ventilators

1815 .....Standard for Nonducted Heat Recovery Ventilators)

G. Department of Veterans Affairs (VA):

PG-18-10 .....HVAC Design Manual

**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 72 00, AIR-TO-AIR ENERGY RECOVERY EQUIPMENT”, 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. Plate Heat Exchanger

D. Certificate: Submit, simultaneously with shop drawings, an evidence of satisfactory service of the equipment on three similar installations.

E. Submit type, size, arrangement, and performance details. Present application ratings in the form of tables, charts, or curves.

F. 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.

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 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

H. 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. Refer to Section 01 00 00, GENERAL REQUIREMENTS for performance tests and instructions to VA personnel.

B. Performance Criteria: Heat recovery equipment shall be provided by a manufacturer who has been manufacturing such equipment and the equipment has a good track record for at least 3 years.

C. 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.

D. Refer to Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS for additional sustainable design requirements.

**1.6 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 AIR-TO-AIR PLATE HEAT EXCHANGER**

A. Comply with UL 1812.

B. Plates: Corrugated 0.53 mm (0.021 inch) polypropylene copolymer (high density plastic)spacing as recommended by the manufacturer.

C. Bedding: Thermosetting reinforced resin. Provide plate seal-off and passage separation at top, bottom and center divider. The resins shall be self-extinguishing type in accordance with ASTM D635.

D. Casing and End Strips: Casing of 1.6 mm (16 gauge) galvanized steel, except casings for corrosive air streams shall be stainless steel. End strips of the same material as exchanger plates. Ends of unit exchanger plates shall be sealed with high temperature silicon sealant prior to installation of end strip for corrosive air streams provide welded end strips to avoid cross contaminations.

E. Casings shall have integral flanges for flanged duct connections and shall have lifting holes or lugs.

F. Drain Pan: Same material as unit casing. Drain pan surface shall be covered with molded ABS and shall have drain connections on exhaust and supply side. Comply with requirements in ASHRAE 62.1.

G. Accessories: Furnish where indicated on the contract drawings.

1. Face and Bypass Dampers: Manufacturer's standard, complete with operators, with factory installed controls to operate face-and-bypass dampers during summer and winter.
2. Defrost System: Factory installed and capable of maintaining at least 85 percent of the non-frosted performance at -29 degrees C (-20 degrees F).

**2.25 AIR FILTERS**

A. Air Filters: Disposable air filters, with a MERV rating of 7, shall be provided standard on all air entering sides of air to air heat exchangers, and as indicated on the contract drawings. Comply with requirements in Section 23 40 00, HVAC AIR CLEANING DEVICES.

**PART 3 - EXECUTION**

**3.1 INSTALLATION**

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. Follow the equipment manufacturer's instructions for handling and installation and setting up of ductwork for makeup and exhaust air steamers for maximum efficiency.

C. Seal ductwork tightly to avoid air leakage.

D. Install units with adequate spacing and access for cleaning and maintenance of heat recovery coils as well as filters.F. Brace heat recovery equipment installed in projects in the seismic area

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

**3.2 FIELD QUALITY CONTROL**

A. Operational Test: Perform tests as per manufacturer's written instructions for proper and safe operation of the heat recovery system.
   1. After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   2. Adjust seals and purge.
   3. Test and adjust controls and safeties.

B. Replace damaged and malfunctioning controls and equipment.

C. Set initial temperature and humidity set points. Set field adjustable switches and circuit breaker trip ranges as indicated.

D. Prepare test and inspection reports to the COR in accordance with Section 01 00 00, GENERAL REQUIREMENTS.

**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.

**3.5 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.

- - - E N D - - -

**SECTION 23 73 00**
**INDOOR CENTRAL-STATION AIR-HANDLING UNITS**

## PART 1 - GENERAL

### 1.1 DESCRIPTION

A. A complete listing of common acronyms and abbreviations are included in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

B. Air handling units including integral components specified herein.

C. Definition of Air Handling Unit (AHU): A factory-fabricated and tested assembly of modular sections consisting of single or multiple plenum fans with direct-drive, coils, filters, and other necessary equipment to perform one or more of the following functions of circulating, cleaning, heating, cooling, humidifying, dehumidifying, and mixing of air. Design capacities of units shall be as scheduled in the contract documents.

### 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 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.

D. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

E. Section 09 91 00, PAINTING.

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 12, GENERAL MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.

I. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.

J. Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.

K. Section 23 07 11, HVAC INSULATION

L. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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

N. Section 23 21 13, HYDRONIC PIPING.

O. Section 23 22 13, STEAM AND CONDENSATE HEATING PIPING.

P. Section 23 31 00, HVAC DUCTS and CASINGS.

Q. Section 23 34 00, HVAC FANS.

R. Section 23 40 00, HVAC AIR CLEANING DEVICES.

S. Section 23 82 16, AIR COILS.

T. Section 26 29 11, MOTOR CONTROLLERS.

**1.3 APPLICABLE PUBLICATIONS**

***Note: From the date contract documents are provided, the Contractor shall use the most current published versions of all listed standards and references below.**

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. Air Conditioning, Heating, and Refrigeration Institute (AHRI):

260 .....Sound Rating of Ducted Air Moving and Conditioning Equipment

410 .....Forced-Circulation Air-Cooling and Air-Heating Coils with Addenda 1, 2 and 3

430 .....Performance Rating of Central Station Air-Handling Unit Supply Fans

C. Air Movement and Control Association International, Inc. (AMCA):

99 .....Standards Handbook

210 .....Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating

D. American Bearing Manufacturers Association (ABMA):

9 .....Load Ratings and Fatigue Life for Ball Bearings

E. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE):

51 .....Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating

170 .....Ventilation of Health Care Facilities

F. American Society for Testing and Materials (ASTM):

A653/A653M.....Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

B117 .....Standard Practice for Operating Salt Spray (Fog) Apparatus

D1654.....Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments

D1735.....Standard Practice for Testing Water Resistance of Coatings Using Water Fog Apparatus

D3359.....Standard Test Methods for Rating Adhesion by Tape Test

G152.....Standard Practice for Operating Open Flame Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials

G. Energy Policy Act of 2005 (P.L.109-58)

H. Military Specifications (Mil. Spec.):

P-21035B.....Paint, High Zinc Dust Content, Galvanizing Repair (Metric)

I. National Fire Protection Association (NFPA):

70 .....National Electrical Code

90A.....Standard for Installation of Air-Conditioning and Ventilating Systems

J. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):

016 .....HVAC Air Duct Leakage Test Manual, 2nd 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 73 00, INDOOR CENTRAL-STATION AIR-HANDLING UNITS”, 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. Submittals for AHUs shall include fans, drives, motors, coils, humidifiers mixing box with outside/return air dampers, filter housings, and all other related accessories. The contractor shall provide custom drawings showing total air handling unit assembly including dimensions, operating weight, access sections, flexible connections, door swings, controls penetrations, electrical disconnect, lights, duplex receptacles, switches, wiring, utility connection points, unit support system, vibration isolators, drain pan, pressure drops through each component (filter, coil etc).

2. Submittal drawings of section or component only will not be acceptable. Contractor shall also submit performance data including performance test results, charts, curves, or certified computer selection data; data sheets; fabrication and insulation details. If the unit cannot be shipped in one piece, the contractor shall indicate the number of pieces that each unit will have to be broken into to meet shipping and job site rigging requirements.

3. Submit sound power levels in each octave band for the inlet and discharge of the fan and at entrance and discharge of AHUs at scheduled conditions. In absence of sound power ratings refer to Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
4. Provide fan curves showing cubic feet per minute, static pressure, efficiency, and horsepower for design point of operation and at maximum design Liters/Second (cubic feet per minute).
5. Submit total fan static pressure, external static pressure, for AHU including total, inlet and discharge pressures, and itemized specified internal losses and unspecified internal losses. Refer to air handling unit schedule in the contract documents.

D. Submit written test procedures two weeks prior to factory testing. Submit written results of factory tests for approval prior to shipping.

E. Submit shipping information that clearly indicates how the units will be shipped in compliance with the descriptions below.
1. Units shall be shipped in one (1) piece where possible and in shrink wrapping to protect the unit from dirt, moisture and/or road salt.
2. If not shipped in one (1) piece, provide manufacturer approved shipping splits where required for installation or to meet shipping and/or job site rigging requirements in modular sections. Indicate clearly that the shipping splits shown in the submittals have been verified to accommodate the construction constraints for rigging as required to complete installation and removal of any section for replacement through available access without adversely affecting other sections.
3. If shipping splits are provided, each component shall be individually shrink wrapped to protect the unit and all necessary hardware (e.g., bolts, gaskets etc.) will be included to assemble unit onsite.
4. Lifting lugs will be provided to facilitate rigging on shipping splits and joining of segments. If the unit cannot be shipped in one piece, the contractor shall indicate the number of pieces that each unit will have to be broken into to meet shipping and job site rigging requirements.

F. 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 instructions for lubrication, filter replacement, motor and drive replacement, and spare parts list.
3. Include complete diagrams of the internal wiring for each item of equipment.
4. Diagrams shall have their terminals identified to facilitate installation, operation, and maintenance.

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 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

H. 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. Comply with requirements in paragraph QUALITY ASSURANCE of Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

B. Air Handling Units Certification:
   1. Air Handling Units with Plenum Fans:
      a. Air Handling Units with a single Plenum Fan shall be certified in accordance with AHRI 430 and tested/rated in accordance with AHRI 260.
      b. Air handling Units with Multiple Fans in an Array shall be tested and rated in accordance with AHRI 430 and AHRI 260.

C. Heating, Cooling, and Air Handling Capacity and Performance Standards: AHRI 430, AHRI 410, ASHRAE 51, and AMCA 210.

D. Performance Criteria:
   1. The fan BHP shall include all system effects for all fans and v-belt drive losses for housed centrifugal fans.
   2. The fan motor shall be selected within the rated nameplate capacity, without relying upon NEMA Standard Service Factor.
   3. 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 Fans Including Plenum Fans: At or near the peak static efficiency but at an appropriate distance from the stall line.
   4. Operating Limits: AMCA 99 and manufacturer’s recommendations.

E. Units shall be factory-fabricated, assembled, and tested by a manufacturer, in business of manufacturing similar air-handling units for at least five (5) years.

F. 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.

G. Refer to Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS for additional sustainable design requirements.

**1.6 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 AIR HANDLING UNITS**

A. General:

1. AHUs shall be fabricated from insulated, solid double-wall galvanized steel without any perforations in draw-through configuration. Galvanizing shall be hot dipped conforming to ASTM A653/A653M and shall provide a minimum of 0.275 kg of zinc per square meter (0.97 oz. of zinc per square foot) (G90). Aluminum constructed units, subject to VA approval, may be used in place of galvanized steel. The unit manufacturer shall provide published documentation confirming that the structural rigidity of aluminum air-handling units is equal or greater than the specified galvanized steel.
2. The contractor and the AHU manufacturer shall be responsible for ensuring that the unit will not exceed the allocated space shown in the contract documents, including required clearances for service and future overhaul or removal of unit components. All structural, piping, wiring, and ductwork alterations of units, which are dimensionally different than those specified, shall be the responsibility of the contractor at no additional cost or time to the Government.
3. AHUs shall be fully assembled by the manufacturer in the factory in accordance with the arrangement shown in the contract documents. The unit shall be assembled into the largest sections possible subject to shipping and rigging restrictions. The correct fit of all components and casing sections shall be verified in the factory for all units prior to

shipment. All units shall be fully assembled, tested, and then split to accommodate shipment and job site rigging. On units not shipped fully assembled, the manufacturer shall tag each section and include air flow direction to facilitate assembly at the job site. Lifting lugs or shipping skids shall be provided for each section to allow for field rigging and final placement of unit.

4. The AHU manufacturer shall provide the necessary gasketing, caulking, and all screws, nuts, and bolts required for assembly. The manufacturer shall provide a factory-trained and qualified local representative at the job site to supervise the assembly and to assure that the units are assembled to meet manufacturer's recommendations and requirements noted in the contract documents. Provide documentation to the Contracting Officer that the local representative has provided services of similar magnitude and complexity on jobs of comparable size. If a local representative cannot be provided, the manufacturer shall provide a factory representative.
5. Gaskets: All door and casing and panel gaskets and gaskets between air handling unit components, if joined in the field, shall be high quality which seal airtight and retain their structural integrity and sealing capability after repeated assembly and disassembly of bolted panels and opening and closing of hinged components. Bolted sections may use a more permanent gasketing method provided they are not disassembled.
6. Structural Rigidity: Provide structural reinforcement when required by span or loading so that the deflection of the assembled structure shall not exceed 1/200 of the span based on a differential static pressure of 2000 Pa (8 inch WG) or higher.

B. Base:

1. Provide a heavy duty steel base for supporting all major AHU components. Bases shall be constructed of wide-flange steel I-beams, channels, or minimum 5 inch high 10 Gauge steel base rails. Welded or bolted cross members shall be provided as required for lateral stability. Contractor shall provide supplemental steel supports as required to obtain proper operation heights for cooling coil condensate drain trap and steam coil condensate return trap as shown in the contract documents.
2. AHUs shall be completely self-supporting for installation on concrete housekeeping pad, steel support pedestals, or suspended as shown in the contract documents.
3. The AHU bases not constructed of galvanized steel shall be cleaned, primed with a rust inhibiting primer, and finished with rust inhibiting exterior enamel.

C. Casing (Including Wall, Floor, and Roof):

1. General: AHU casing shall be constructed as solid double wall, galvanized steel insulated panels without any perforations, integral of or attached to a structural frame. The thickness of insulation, mode of application and thermal breaks shall be such that there is no visible condensation on the exterior panels of the AHU located in the non-conditioned spaces.
2. Casing Construction:

| | |
|---|---|
| Outer Panel | 22 Gauge Minimum |
| Inner Panel | 22 Gauge Minimum |
| Insulation<br>Thickness<br>Density | Foam<br>2 inch Minimum<br>3.0 lb/ft$^3$ Minimum |
| Total R Value | 13.0 ft$^2$.$^O$F.hr/Btu<br>Minimum |

3. Casing Construction (Contractor's Option):

| | |
|---|---|
| Outer Panel | 18 Gauge Minimum |
| Inner Panel | 20 Gauge Minimum |
| Insulation<br>Thickness<br>Density | Fiberglass<br>2 inch Minimum<br>1.5 lb/ft$^3$ Minimum |
| Total R Value | 8.0 ft$^2$.$^O$F.hr/Btu<br>Minimum |

4. Blank-Off: Provide blank-offs as required to prevent air bypass between the AHU sections, around coils, and filters.
5. Casing panels shall be secured to the support structure with stainless-steel or zinc-chromate plated screws and gaskets installed around the panel perimeter. Panels shall be completely removable to allow removal of fan, coils, and other internal components for future maintenance, repair, or modifications. Welded exterior panels are prohibited.
6. Access Doors: Provide in each access section and where shown in the contract documents. Show single-sided and double-sided access doors with door swings on the floor plans. Doors shall be a minimum of 2 inch thick with same double wall construction as the unit casing.

Doors shall be a minimum of 24 inches wide, unless shown of different size in the contract documents, and shall be the full casing height up to a maximum of 6 feet. Doors shall be gasketed, hinged, and latched to provide an airtight seal. The access doors for fan section, mixing box, humidifier coil section shall include a minimum 6 inch x 6 inch double thickness, with air space between the glass panes tightly sealed, reinforced glass or Plexiglas window in a gasketed frame.

a. Hinges: Manufacturer's standard, designed for door size, weight and pressure classifications. Hinges shall hold door completely rigid with minimum 100 lb weight hung on latch side of door.

b. Latches: Non-corrosive alloy construction, with operating levers for positive cam action, operable from either inside or outside. Doors that do not open against unit operating pressure shall allow the door to ajar and then require approximately 45 degrees further movement of the handle for complete opening. Latch shall be capable of restraining explosive opening of door with a force not less than 8 inch WG.

c. Gaskets: Neoprene, continuous around door, positioned for direct compression with no sliding action between the door and gasket. Secure with high quality mastic to eliminate possibility of gasket slipping or coming loose.

7. Provide sealed sleeves, metal or plastic escutcheons or grommets for penetrations through casing for power and temperature control wiring and pneumatic tubing. Coordinate with electrical and temperature control subcontractors for number and location of penetrations. Coordinate lights, switches, and duplex receptacles and disconnect switch location and mounting. All penetrations and equipment mounting may be provided in the factory or in the field. All field penetrations shall be performed neatly by drilling or saw cutting. No cutting by torches will be allowed. Neatly seal all openings airtight.

D. Floor:

1. Unit floor shall be level without offset space or gap and designed to support a minimum of 91 lbs per square foot distributed load without permanent deformation or crushing of internal insulation. Provide adequate structural base members beneath floor in service access sections to support typical service foot traffic and to prevent damage to unit floor or internal insulation. Unit floors in casing sections, which may contain water or condensate, shall be watertight with drain pan.

2. Where indicated, furnish and install floor drains flush with the floor, with nonferrous grate cover and stub through floor for external connection.

E. Condensate Drain Pan: Drain pan shall be designed to extend entire length of cooling coils including headers and return bends. Depth of drain pan shall be at least 1.7 inches and shall handle all condensate without overflowing. Drain pan shall be double-wall, double sloping type, and fabricated from stainless-steel (304) with at least (2 inch thick insulation sandwiched between the inner and outer surfaces. Drain pan shall be continuous metal or welded watertight. No mastic sealing of joints exposed to water will be permitted. Drain pan shall be placed on top of casing floor or integrated into casing floor assembly. Drain pan shall be pitched in all directions to drain line.

1. An intermediate, stainless-steel (304) condensate drip pan with copper downspouts shall be provided on stacked cooling coils. Use of intermediate condensate drain channel on upper casing of lower coil is permissible provided it is readily cleanable. Design of intermediate condensate drain shall prevent upper coil condensate from flowing across face of lower coil.
2. Drain pan shall be piped to the exterior of the unit. Drain pan shall be readily cleanable.
3. Installation, including frame, shall be designed and sealed to prevent blow-by.

F. Plenum Fans – Single and/or Multiple Fans in an Array:

1. General: Fans shall be Class II (minimum) construction with single inlet, aluminum wheel and stamped air-foil aluminum bladed. The fan wheel shall be mounted on the directly-driven motor shaft in AMCA Arrangement 4. Fans shall be dynamically balanced and internally isolated to minimize the vibrations. Provide a steel inlet cone for each wheel to match with the fan inlet. Locate fan in the air stream to assure proper flow. The fan performance shall be rated in accordance with AMCA 210 or ASHRAE 51.
2. Allowable vibration tolerances for fan shall not exceed a self-excited vibration maximum velocity of 0.20 inch per second RMS, filter in, when measured with a vibration meter on bearing caps of machine in vertical, horizontal, and axial directions or measured at equipment mounting feet if bearings are concealed. After field installation, compliance to this requirement shall be demonstrated with field test in accordance with Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT and Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC. Following fan assembly, the complete fan assembly balance shall be tested using an electronic balance analyzer with a tunable filter and stroboscope. Vibration measurements shall be taken on each motor bearing

housing in the vertical, horizontal, and axial planes (5 total measurements, 2 each motor bearing and 1 axial).

3. The plenum fans shall be driven by variable speed drives with at least one back-up drive as shown in the design documents. Use of a drive with bypass is prohibited.
4. Multiple fans shall be installed in a pre-engineered structural frame to facilitate fan stacking. All fans shall modulate in unison, above or below the synchronous speed within the limits specified by the manufacturer, by a common control sequence. Staging of the fans is prohibited. Redundancy requirement shall be met by all operating fans in an array and without the provision of an idle standby fan.
5. Fan Accessories:
    a. Fan Airflow Measurement: Provide an airflow measuring device integral to the fan to measure air volume within +/- 5 percent accuracy. The probing device shall not be placed in the airflow path to stay clear of turbulence and avoid loss of performance.

G. Filter Section: Refer to Section 23 40 00, HVAC AIR CLEANING DEVICES, for filter requirements.
1. Filters including one complete set for temporary use at site shall be provided independent of the AHU. The AHU manufacturer shall install filter housings and racks in filter section compatible with filters furnished. The AHU manufacturer shall be responsible for furnishing temporary filters (pre-filters and after-filters, as shown in the contract documents) required for AHU testing.
2. Factory-fabricated filter section shall be of the same construction and finish as the AHU casing including filter racks and hinged double wall access doors. Filter housings shall be constructed in accordance with side service or holding frame housing requirements in Section 23 40 00, HVAC AIR CLEANING DEVICES.

H. Coils: Coils shall be mounted on hot dipped galvanized steel supports to assure proper anchoring of coil and future maintenance. Coils shall be face or side removable for future replacement thru the access doors or removable panels. Each coil shall be removable without disturbing adjacent coil. Cooling coils shall be designed and installed to ensure no condensate carry over. Provide factory-installed extended supply, return, drain, and vent piping connections. Refer to the contract documents and Section 23 82 16, AIR COILS for additional coil requirements.

I. Humidifier: When included in design, coordinate the humidification requirements with Section 23 22 13 STEAM AND CONDENSATE HEATING PIPING. Provide air-handling unit-mounted humidification section with stainless-steel drain pan of adequate length to allow complete

absorption of water vapor. Provide stainless-steel dispersion panel or distributors as indicated, with stainless-steel supports and hardware.

T. Electrical and Lighting: Wiring and equipment specifications shall conform to Division 26, ELECTRICAL.
   1. Disconnect switch and power wiring: Provide factory or field mounted disconnect switch. Coordinate with Division 26, ELECTRICAL.
   2. Provide single point power connection. Coordinate with Division 26, ELECTRICAL.

**PART 3 – EXECUTION**

**3.1 INSTALLATION**

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. Install air handling unit in conformance with AHRI 430.

C. Assemble air handling unit components following manufacturer's instructions for handling, testing and operation. Repair damaged galvanized areas with paint in accordance with Mil. Spec. P-21035B. Repair painted units by touch up of all scratches with finish paint material. Vacuum the interior of air handling units clean prior to operation.

D. Leakage and test requirements for air handling units shall be the same as specified for ductwork in Section 23 31 00, HVAC DUCTS AND CASINGS except leakage shall not exceed Leakage Class ($C_L$) 12 listed in SMACNA HVAC Air Duct Leakage Test Manual when tested at 1.5 times the design static pressure. Repair casing air leaks that can be heard or felt during normal operation and to meet test requirements.

E. Perform field mechanical (vibration) balancing in accordance with Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.

F. Seal and/or fill all openings between the casing and AHU components and utility connections to prevent air leakage or bypass.

**3.2 STARTUP AND TESTING**

A. The air handling unit shall not be operated for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings are lubricated, and the fan has been test run under observation.

B. After the air handling unit is installed and tested, provide startup and operating instructions to VA personnel.

C. An authorized factory representative should startup, test, and certify the final installation and application specific calibration of control components. Items to be verified include fan performance over entire operating range, noise and vibration testing, verification of proper alignment, overall inspection of the installation, Owner/Operator training, etc.

D. 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.

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

F. 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.

**3.3 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.

**3.4 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.

- - - E N D - - -

**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. A complete listing of common acronyms and abbreviations are included in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

C. Definitions:

1. Energy Efficiency Ratio (EER): A ratio calculated by dividing the cooling capacity in Btu per hour by the power input in watts at any given set of rating conditions, expressed in Watts (Btu/h) per watt.
2. Integrated Energy Efficiency Ratio (IEER): Calculated by weighting the EER values at different load capacities and adding them together. The formula is based in the approximate number of hours a unit spends at each load point throughout its life. A minimum of four loads points are used for the calculation.
3. 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.
4. 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.
5. CRAC Units: Computer Room Air Conditioning Units.

## 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 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.

D. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON–STRUCTURAL COMPONENTS.

E. Section 22 05 23, GENERAL-DUTY VALVES FOR PLUMBING PIPING.

F. Section 22 11 00, FACILITY WATER DISTRIBUTION.

G. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

H. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION EQUIPMENT.

I. Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.

J. Section 23 05 93: TESTING, ADJUSTING, and BALANCING FOR HVAC.

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 23 21 13, HYDRONIC PIPING.

O. Section 23 22 13, STEAM and CONDENSATE HEATING PIPING.

P. Section 23 23 00, REFRIGERANT PIPING.

Q. Section 23 31 00, HVAC DUCTS and CASINGS.

R. Section 23 40 00, HVAC AIR CLEANING DEVICES.

## 1.3 SUBMITTALS

A. Submit in accordance with specification 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 81 23, COMPUTER-ROOM-AIR-CONDITIONERS”, with applicable paragraph identification.

C. Manufacturer’s Literature and Data Including: 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 Unit
2. Glycol Pump Package
3. Dry Cooler
4. Air Cooled Condensing Unit

D. Submit detailed equipment assemblies with dimensions, operating weights, required clearances.

E. Submit wiring diagrams for power, alarm and controls.

F. Certification: Submit, simultaneously with shop drawings, a proof of certification:

G. Completed System Readiness Checklists 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 23 08 00 COMMISSIONING OF HVAC SYSTEMS.

H. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

## 1.4 QUALITY ASSURANCE

A. Refer to specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

## 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 warranty period.

## 1.6 APPLICABLE PUBLICATIONS

***Note: From the date contract documents are provided, the Contractor shall use the most current published versions of all listed standards and references below.**

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. Air Conditioning, Heating and Refrigeration Institute (AHRI) Standards:

210/240 ..... Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment

340/360 ..... Performance Rating of Commercial and Industrial Unitary Air Conditioning and Heat Pump Equipment

410 ..... Forced-Circulation Air-Cooling and Air-Heating Coils

460 ..... Performance Rating of Remote Mechanical-Draft Air-Cooled Refrigerant Condensers

520 ..... Performance Rating of Positive Displacement Condensing Units

DCPP (Web-based) ..... Directory of Certified Product Performance - Applied Directory of Certified Products

C. Air Movement and Control Association (AMCA):

210 ..... Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating (ANSI)

410 ..... Recommended Safety Practices for Users and Installers of Industrial and Commercial Fans

D. American Society of Heating, Refrigerating, and Air-Conditioning Engineers Inc. (ASHRAE):

15 ..... Safety Standard for Refrigeration Systems

34 ..... Designation and Classification of Refrigerants (ANSI)

52.1withdrawn) Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices used in General Ventilation for Removing Particulate Matter

62-1 ..... Ventilation for Acceptable Indoor Air Quality (ANSI)

90.1 ..... Energy Standard for Buildings except Low-Rise Residential Buildings (ANSI Approved; IES Co-sponsored)

..... HVAC Systems and Equipment Handbook

..... Refrigeration Handbook

E. American Society of Testing and Materials (ASTM):

B117 ..... Standard Practice for Operating Salt Spray (Fog) Apparatus

F. National Electrical Manufacturer's Association (NEMA):

MG 1..... Motors and Generators (ANSI)

G. National Fire Protection Association (NFPA) Publications:

70 ..... National Electrical Code

90A ..... Standard for the Installation of Air-Conditioning and Ventilating Systems

H. Department of Veterans Affairs (VA):

PG-18-10 ..... HVAC Design Manual

**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 CONSOLE UNITS**

A. Description: Split system consisting of evaporator section for floor or wall mounting and remote condensing section.

B. Evaporator Cabinet: Furniture-grade steel with baked-enamel finish; with front access and containing direct-drive centrifugal fans and two-speed motor.

C. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2007.

D. Condenser Cabinet: Steel with baked-enamel finish and containing compressor and condenser.

E. Compressor: Semi Hermetic scroll with oil strainer, internal motor overload protection, resilient suspension system, and crankcase heater.

F. Refrigeration Circuit: Filter/dryer, manual-reset high-pressure switch, thermal-expansion valve with external equalizer, sight glass with moisture indicator, service shutoff valves, charging valves, and charge of refrigerant.

G. Use refrigerant type ___R407C__. EPA approved refrigerants are listed at https://www.epa.gov/snap/. Submit proposed refrigerant for government approval.

H. Refrigerant Evaporator Coil: Direct-expansion coil of seamless copper tubes expanded into aluminum fins.

1. Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1 and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir.

I. Remote Air-Cooled Refrigerant Condenser: Integral aluminum-fin coil with plenum fan, direct driven.

J. Split system shall have suction- and liquid-line compatible fittings and refrigerant piping for field interconnection.

K. Hydronic Cooling Coil: Seamless copper tubes expanded into aluminum fins with modulating control valve.

1. Cooling Medium: Water.
2. Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1 and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir.

L. Filter: Disposable, glass-fiber media.

1. Arrestance: 90 percent according to ASHRAE 52.1.
2. MERV Rating: 7 according to ASHRAE 52.2.

M. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.

N. Control System: Unit-mounted panel with contactors, control transformer with circuit breaker, and solid-state temperature control modules. Wall-mounted control panel shall be solid-state, with start-stop switch and adjustable temperature set point.

O. DDC or BAS Interface: Provide connection to the DDC or the BAS system.

**2.2 FAN MOTORS**

A. Default motor characteristics are specified in Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC.

B. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION EQUIPMENT.

C. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

D. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.

**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 CORROSION CONTROL**

A. Remote Outdoor Condenser Coils:

1. Epoxy Immersion Coating – Electrically Deposited: The multi-stage corrosion-resistant coating application comprises of cleaning (heated alkaline immersion bath) and reverse-osmosis immersion rinse prior to the start of the coating process. The coating thickness shall be maintained between 0.6-mil and 1.2-mil. Before the coils are subjected to high-temperature oven cure, they are treated to permeate immersion rinse and spray. Where the coils are subject to UV exposure, UV protection spray treatment comprising of UV-resistant urethane mastic topcoat shall be applied. Provide complete coating process traceability for each coil and minimum five years of limited warranty. The coating process shall be such that uniform coating thickness is maintained at the fin edges. The quality control shall be maintained by ensuring compliance to the applicable ASTM Standards for the following:
    a. Salt Spray Resistance (Minimum 6,000 Hours)
    b. Humidity Resistance (Minimum 1,000 Hours)
    c. Water Immersion (Minimum 260 Hours)
    d. Cross-Hatch Adhesion (Minimum 4B-5B Rating)
    e. Impact Resistance (Up to 160 Inch/Pound)

B. Exposed Outdoor Cabinet

1. Casing Surfaces (Exterior and Interior): All exposed and accessible metal surfaces shall be protected with a water-reducible acrylic with stainless steel pigment spray-applied over the manufacturer's standard finish. The spray coating thickness shall be 2-4 mils and provide minimum salt-spray resistance of 1,000 hours (ASTM B117) AND 500 hours UV resistance (ASTM D4587).

**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 and Condensate Piping, as specified in specification Section 23 21 13, and HYDRONIC PIPING.

E. Fill glycol system with 40 percent glycol mixture and perform start-up procedures as recommended by the manufacturer.

F. 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. Drainage Connections: Comply with applicable requirements in Section 22 05 23, GENERAL-DUTY VALVES FOR PLUMBING PIPING. Provide adequate connections for condensate drain.

E. Refrigerant Piping: Comply with applicable requirements in Section 23 23 00, REFRIGERANT PIPING. Provide shutoff valves and piping.

**3.3 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.

**3.4 STARTUP AND TESTING**

A. The CxA and COR will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the COR and CxA. Provide a minimum of 7 days prior notice.

B. Provide services of manufacturer's technical representative for four hours to instruct VA personnel in operation and maintenance of computer room air conditioning equipment.

**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 CxA.

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 43**
**AIR-SOURCE UNITARY HEAT PUMPS**

## PART 1 - GENERAL

### 1.1 DESCRIPTION

A. This Section specifies electrically operated air-source unitary heat pumps.

B. A complete listing of common acronyms and abbreviations are included in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

C. Definitions:

1. Coefficient of Performance (COP) - Cooling: The ratio of the rate of heat removed to the rate of energy input in consistent units, for a complete refrigerating system or some specific portion of that system under designated operating conditions.
2. Coefficient of Performance (COP) - Heating: The ratio of the rate of heat delivered to the rate of energy input is consistent units for a complete heat pump system, including the compressor and, if applicable, auxiliary heat under designated operating conditions.
3. 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.
4. Heating Seasonal Performance Factor (HSPF) - Total heating output of heat pump during its normal annual usage period for heating in Btu/h divided by total electric energy input in watts during the same period.
5. Seasonal Energy Efficiency Ratio (SEER) - 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.
6. Air-Source Unitary Heat Pump: One or more factory made assemblies that normally include an indoor conditioning coil, compressor(s) and an outdoor refrigerant-to-air coil. These units provide both heating and cooling functions.

### 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 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.

D. Section 01 91 00 – GENERAL COMMISSIONING REQUIREMENTS.

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 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 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

B. Comply with ASHRAE Standard 15, Safety Code for Mechanical Refrigeration.

C. Comply with ASHRAE Standard 90.1, Energy Standard for Buildings except Low-Rise Residential Buildings for cooling and heating performance requirements when tested in accordance with AHRI 210/240 AHRI 340/360 and UL 1995.

D. Heating Performance shall conform to ASHRAE requirements when tested in accordance with AHRI 210/240 AHRI 340/360 and UL 1995.

E. Comply with requirements in Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

**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 Including:

1. Air-Source Unitary Heat pump:
    a. Packaged units
    b. Split system

C. Certification: Submit, simultaneously with shop drawings, a proof of certification that this product has been certified by AHRI.

D. Performance Rating: Submit catalog selection data showing equipment ratings and compliance with required cooling and heating capacities EER and COP values as applicable.

E. Completed System Readiness Checklists 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 23 08 00 COMMISSIONING OF HVAC SYSTEMS.

**1.5 APPLICABLE PUBLICATIONS**

***Note: From the date contract documents are provided, the Contractor shall use the most current published versions of all listed standards and references below.**

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. Federal Specification (Fed. Spec.):

A-A-50502 .....Air-conditioner (UNITARY HEAT PUMP), AIR TO AIR (3000 TO 300,000 BTUH)

C. Air-Conditioning Heating and Refrigeration Institute (AHRI) Standards:

DCPP(Web-based).....Directory of Certified Product Performance - Applied Directory of Certified Products

210/240.....Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment

270 .....Sound Rating of Outdoor Unitary Equipment

310/380.....Standard for Packaged Terminal Air-Conditioners and Heat Pumps (CSA-C744-04)

340/360.....Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment

D. Air Movement and Control Association (AMCA):

210 .....Laboratory Methods of Testing Fans for Aerodynamic Performance Rating (ANSI)

410 .....Recommended Safety Practices for Users and Installers of Industrial and Commercial Fans

E. American National Standards Institute (ANSI):

S12.51 .....Acoustics - Determination of Sound Power Levels of Noise Sources Using Sound Pressure - Precision Method for Reverberation Rooms (same as ISO 3741:1999)

F. American Society of Heating, Refrigerating and Air-Conditioning Engineers Inc. (ASHRAE):

15 .....Safety Standard for Refrigeration Systems (ANSI)

62.1 .....Ventilation for Acceptable Indoor Air Quality (ANSI)

90.1 .....Energy Standard for Buildings except Low-Rise Residential Buildings

.....HVAC Systems and Equipment Handbook

G. American Society of Testing and Materials (ASTM):

B117 .....Standard Practice for Operating Salt Spray (Fog) Apparatus

D4587.....Standard Practice for Fluorescent UV-Condensation Exposures of Paint and Related Coatings

H. National Electrical Manufacturer's Association (NEMA):

ICS 1.....Industrial Controls and Systems: General Requirements

MG 1.....Motors and Generators (ANSI)

I. National Fire Protection Association (NFPA):

90A.....Standard for the Installation of Air-Conditioning and Ventilating Systems

J. Underwriters Laboratory (UL):

1995 .....Heating and Cooling Equipment

**1.6 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 UNITARY HEAT PUMPS, AIR TO AIR**

A. Units shall comply with Fed Spec A-A-50502Type I, having factory assembled refrigerant circuit or circuits (Packaged Unit), Type II, (Split System) having remote outdoor section separate from indoor Section, Class 1, "Department of Energy" (DOE) covered products (units with cooling capacity up to 65000 Btu/hr Class 2, Non–DOE covered products (units with cooling capacity up to 300,000 Btu/hr .

1. Unitary heat pumps shall bear the United States Environmental Protection Agency, Energy Star label and shall have a minimum Heating Season Performance Factor (HSPF) of 8 (Type I – Packaged Unit),8.2 (Type II – Split System), and a minimum Seasonal Energy Efficiency Ratio (SEER) of 14 (Type I – Packaged Unit),14.5 (Type II – Split System).

B. Applicable AHRI Standards: Units shall be listed in the corresponding ARI Directory of Certified products shown in paragraph, APPLICABLE PUBLICATIONS:

1. Air Source Unitary heat pumps with capacity less than 19 KW (65,000 Btu/hr), Comply with AHRI 210/240.

C. Casing: Unit shall be constructed of zinc coated, 14-gage minimum galvanized steel. Exterior surfaces shall be cleaned, phosphatized, and finished with a weather-resistant baked enamel

finish. Unit surfaces shall be tested 500 hours in a salt spray test in compliance with ASTM B117. Cabinet panels shall have lifting handles and shall be water- and air-tight seal. All exposed vertical, top covers and base pan shall be insulated with 13-mm (1/2–inch) matt-faced, fire-resistant, odorless, glass fiber material. Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1. The base of the unit shall have provisions for forklift and crane lifting.

D. Filters: One inch, MERV 7, throwaway filter shall be standard on all units below 19kW (6 Tons). Filter rack can be converted to two-inch capability. Two inch, MERV 8, throwaway filters shall be factory supplied on all units above 19 kW (6 Tons).

E. Compressors: Compressors shall be direct-drive, hermetic scroll type with centrifugal type oil pumps. Motor shall be suction gas-cooled. Internal overloads and crankcase heaters shall be utilized with all compressors.

F. Refrigerant Circuit: A minimum of two circuits is required. Each refrigerant circuit shall have independent fixed orifice or thermostatic expansion devices, service pressure ports, and refrigerant line filter driers factory installed as standard. An area shall be provided for replacement suction line driers.

G. Evaporator and Condenser Coils: Internally finned, DN 10 (NPS 3/8) copper tubes mechanically bonded to a configured aluminum plate fin shall be standard. The evaporated coil and condenser coil shall be leak tested at the factory to 1378 kPa (200 psig) and pressure tested to 2756 kPa (400 psig). All dual compressor units shall have intermingled evaporator coils. Sloped condensate drain pans shall be provided.

H. Outdoor fans: Direct driven, statically and dynamically balanced, draw-through in the vertical discharge position. The fan motors shall be permanently lubricated and shall have built-in thermal overload protection.

I. Indoor Fan:

1. Forward-Curved, Centrifugal Fan: Provide V-belt driven with adjustable motor sheaves adjustable idler-arm assembly for quick-adjustment of fan belts and motor sheaves. Motors shall be thermally protected. Provide oversized motors for high static application. Motors shall meet the U.S. Energy Policy Act of 2005 (EPACT).
2. Plenum Fans Provide direct-drive, Arrangement 4, plenum fan(s) equipped with variable-speed drives. Maximum fans in an array shall not exceed four.

J. Defrost Controls: A time initiated, temperature terminated defrost system shall ship with a setting of 70-minute cycle, with a choice of 50- or 90-minute cycle. Timed override limits defrost cycle to 10 minutes shall be available on units from 35- to 70-kW (10 to 20 tons). Adaptive demand defrost shall be provided on units below 35 kW (10 Tons).

K. Unit Electrical

1. Provide single point unit power connection.
2. Unit control box shall be located within the unit and shall contain controls for compressor, reversing valve and fan motor operation and shall have a 50 VA 24-volt control circuit transformer and a terminal block for low voltage field wiring connections.
3. Safety Controls - High pressure, low temperature, and low-pressure safety switches shall be wired through a latching lockout circuit to hold the conditioner off until it is reset electrically be interrupting the power supply to the conditioner. All safety switches shall be normally closed, opening upon fault detection.
4. Unit DDC Controller:
    a. Unit controller shall include input, output and self-contained programming as needed for complete control of unit.
    b. Unit controller shall be BAC net compliant and utilize BAC net operating protocol.
    c. Control system shall seamlessly interface with temperature control system as specified in Section 23 09 23, DIRECT DIGITAL CONTROL SYSTEMS FOR HVAC without requiring gateways or any other interface devices.
    d. All program sequences shall be stored on board in EEPROM. No batteries shall be needed to retain logic program. All program sequences shall be executed by controller 10 times per second and shall be capable of multiple PID loops for control of multiple devices. Programming of logic controller shall be completely modifiable in the field over installed BACnet LANs.
    e. Temperature Control System Interface: Points shall be available from the unit controller for service access and display and/or control.
    f. Space Temperature Sensor: The wall mounted sensor shall include occupied and unoccupied setpoint control, pushbutton unoccupied override, space temperature offset and space temperature indication. Refer to Section 23 09 23, DIRECT DIGITAL CONTROL SYSTEM FOR HVAC for additional requirements.

L. Accessories:

1. Electric Heater: Constructed of heavy-duty nickel chromium elements. Staging shall be achieved through the unit control processor. Each heater shall have automatically reset high limit control. Heaters shall be individually fused from the factory and shall comply with NEC and CEC requirements. Power assemblies shall provide single point connection. Electric heat modules shall be listed and labeled by a national recognized testing laboratory acceptable to authorities having jurisdiction. Electric heater controls shall confirm the supply fan is operating before electric elements are energized. Operate electric heater in 2 stages when outdoor ambient is too low to maintain space thermostat setting with compressor operation.
2. Oversized Motors: Factory Field installed over sized motor shall be available for high-static application.

**PART 3 - EXECUTION**

**3.1 INSTALLATION**

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. Install heat pumps according to manufacturers printed instructions.

C. Install electrical and control devices furnished by the manufacturer but not specified to be factory mounted. All electrical work shall comply with Division 26 Sections.

D. Ductwork: Comply with requirements in Section 23 31 00, HVAC DUCTS AND CASINGS.

E. Piping: Comply with requirements in Section 23 23 00, REFRIGERANT PIPING.

**3.2 STARTUP AND TESTING**

A. Perform startup checks according to manufacturer’s written instructions.

B. 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 7 working days prior to startup and testing.

C. Test controls and demonstrate its compliance with project requirements. Replace damaged or malfunctioning controls and equipment and retest the equipment to the satisfaction of the COR.

D. Furnish test reports to the COR in accordance with specification Section 01 00 00, GENERAL REQUIREMENTS.

**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 CxA.

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.

**3.4 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 23 82 00**
**CONVECTION HEATING AND COOLING UNITS**

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

A. A complete listing of common acronyms and abbreviations are included in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

B. This section specifies room fan-coil units and unit heaters

**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 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.

D. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

E. 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.

L. Section 23 82 16, AIR COILS.

**1.3 APPLICABLE PUBLICATIONS**

***Note: From the date contract documents are provided, the Contractor shall use the most current published versions of all listed standards and references below.**

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. Air-Conditioning, Heating, and Refrigeration Institute (ANSI/AHRI):

440 .....Performance Rating of Fan-Coil Units

C. National Fire Protection Association (NFPA):

70 .....National Electrical Code

90A.....Standard for the Installation of Air-Conditioning and Ventilating Systems

D. Underwriters Laboratories, Inc. (UL):

181 .....Standard for Factory-Made Air Ducts and Air Connectors

1995 .....Heating and Cooling 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 23 82 00, Convection Cooling and Heating Units”, 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. Induction units.
2. Room Fan-Coil units.
3. Unit heaters.

D. Certificates:

1. Compliance with paragraph QUALITY ASSURANCE.
2. Compliance with specified standards.

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. Completed System Readiness Checklists 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 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

G. 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. Refer to paragraph QUALITY ASSURANCE of Section 23 05 11, COMMON WORK RESULTS FOR HVAC. Provide guarantee in accordance with FAR clause 52.246-21.

B. 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.

C. Refer to Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS for additional sustainable design requirements.

**1.6 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 INDUCTION UNITS**

A. General: Induction units shall include an enclosure for cabinet models and casing for concealed models. Base unit shall include air plenums, air-discharge nozzles, air discharge grilles, recirculation grilles, water coil assembly, valve and piping package, condensate drain pan, and an adjustable air-balancing damper. Each unit shall be selected to produce the capacity shown in the contract documents, without exceeding the specified static pressure.

B. Enclosure: Construct of galvanized steel minimum 1.3 mm (l8 gauge), reinforced and braced. Front panel of enclosure shall be removable. Discharge grilles shall be adjustable and shall be of such design as to distribute air throughout the conditioned space. Plastic discharge and return grilles are prohibited. Provide access doors for all piping and control compartments. Color of the enclosure shall be manufacturer's standard.

C. Air Plenums: Construct air plenums of galvanized steel with interior acoustically baffled and lined with sound absorbing materials that will attenuate the sound power from the primary air supply to the room. Lining shall be 13 mm (1/2 inch) thick (2.5 lb/ft3) density neoprene coated glass fiber. Heat-resistant nozzles shall be integral with or attached airtight to the plenum. Where coil induction units are supplied with vertical runouts, provide a streamlined, vaned, mitered elbow transition piece for connection between the unit and ductwork. Provide an adjustable air-balancing damper in each unit.

D. Water Coils: Provide dual water coils for heating and cooling. Seamless copper tubing, with copper or aluminum fins, mechanically bonded or soldered to the tubes, suitable for 1380 kPa (200 psig) working pressure. Provide coil connections with no less than 11 mm (7/16-inch)

outside diameter flare or sweat connectors, accessory piping package with shut-off valves and terminal connections suitable for connection to the type of control valve supplied, and manual air vent. Test coils hydrostatically at 2070 kPa (300 psig) or under water at 1724 kPa (250 psig) air pressure. Refer to the contract documents and Section 23 82 16, AIR COILS, for additional coil requirements.

E. Provide easily accessible 25 mm (1 inch) thick throwaway type MERV 8 filters for each unit.

F. Drain or Auxiliary Pans: Galvanized steel, watertight, and properly sized and located to collect all condensed water dripping from any item within the unit enclosure. Provide drain connection when a condensate drain system is indicated. Connection shall be minimum 15 mm (l/2-inch) NPT.

**2.2 ROOM FAN-COIL UNITS**

A. Capacity Certification: AHRI 440.

B. Safety Compliance: NEC compliant and UL listed.

C. Noise Levels: Operating at full cooling capacity, sound power level shall not exceed by more than 5 dB the numerical value of sound pressure levels associated with noise criteria specified in Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT. Select units at intermediate speed, for compliance with the noise criteria.

D. Chassis: Galvanized steel, acoustically and thermally insulated to attenuate noise and prevent condensation.

E. Cabinet: Minimum 1.3 mm (l8 gauge) steel reinforced and braced. Arrange components and provide adequate space for installation of piping package and control valves. Finish shall be factory-baked enamel in manufacturer’s standard color on all exposed surfaces.

1. Vertical Exposed Cabinet Unit: Provide 1.6 mm (l6 gauge) steel front panel with 13 mm (l/2 inch) thick fiberglass insulation and provide screw-type levelers. Provide low-silhouette type where shown.
    a. Air Outlet Grilles: Adjustable four-way air deflection located in the top panel.
    b. Provide two hinged access doors (one each side) equipped with key operated cam-lock fasteners in the unit top panel located to provide access to the unit controls.

F. Fans: Centrifugal, forward curved, double width type wheels, galvanized steel or polyester resin construction, statically and dynamically balanced, direct driven.

1. Motors: Premium efficiency, 3-speed permanent split capacitor type with integral thermal overload protection, for operation at no greater than l200 RPM.

2. Provide a fan speed selector switch, with off, low, medium, and high positions. Switch shall have a set of auxiliary contacts which are open when the switch is in the “off” position and closed when the switch in any of the other positions. On vertical units, mount switch in a junction box in the cabinet of each unit. On ceiling-suspended horizontal and concealed units, switch shall be wall mounted.

G. Cooling and Heating Coils:

1. Hydronic (two separate coils for cooling and heating): Copper tubes, 10 mm (3/8 inch) minimum inside diameter, not less than 0.43 mm (0.0l7 inch) thick with copper or aluminum fins. Coils shall be pressure tested for bursting and strength in accordance with Underwriters Laboratories, Inc., requirements for pressure tested coils, and shall be designed to provide adequate heat transfer capacity. Provide manual air vent at high point of each coil and drain at each low point.

H. Piping Package: Factory furnished with unit by the manufacturer or field-installed by the contractor to fit control valves provided by the controls’ supplier. Submit manufacturer’s detailed drawings of the piping in the end compartments for approval prior to fabrication of the piping packages. Provide ball stop valves on the supply and return pipes and balancing fittings on the return pipes.

I. Drain Pans: Furnish galvanized steel with solderless drain connections and molded polystyrene foam insulating liner:

1. Auxiliary Drain Pan: Located under control valve and piping within the unit enclosure to prevent dripping.

2. Secondary Drain Pan: Where the unit is located such that drain pan overflow will damage the building provide a secondary drain pan located provided with a separate drain line discharging to conspicuous point.

J. Air Filter: Manufacturer’s standard throwaway type, not less than 25 mm (1 inch) thick, MERV 7, supported to be concealed from sight and be tight fitting to prevent air by-pass. Filters shall have slide out frames and be easily replaced without removing enclosure or any part thereof.

K. Control valves and remote wall mounted space thermostats are to be field installed. Provide two-way modulating control valves unless shown or specified otherwise.

**2.3 UNIT HEATERS**

A. General: Horizontal or vertical discharge type for hot water as indicated.

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.
2. Vertical Discharge: Radial louver diffuser.

E. Hot Water Coil: Aluminum fins bonded to seamless copper tubing by mechanical expansion of the tubing, designed for 520 kPa (75 psig) working pressure.

F. Controls: Provide field installed remote wall mounted line voltage electric space thermostats to control the unit fan. Provide an aquastat on hot water units to prevent fan operation when the heating system is off.

**PART 3 - EXECUTION**

**3.1 INSTALLATION**

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. Work shall be installed as shown and according to the manufacturer's diagrams and recommendations.

C. Handle and install units in accordance with manufacturer's written instructions.

D. 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.

E. Install fiberglass blanket insulation with a minimum R value of 8 above hydronic radiant panels.

**3.2 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 o startup and testing.

**3.3 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.

**3.4 DEMONSTRATION AND TRAINING**

A. Provide services of manufacturer's technical representative for 4 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 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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**SECTION 23 82 16**
**AIR COILS**

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

A. A complete listing of common acronyms and abbreviations are included in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

B. Heating and cooling coils for air handling units and duct applications.

**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 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.

D. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

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 08 00, COMMISSIONING OF HVAC SYSTEMS.

H. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEMS for HVAC.

I. Section 23 31 00, HVAC DUCTS AND CASINGS.

J. Section 23 36 00, AIR TERMINAL UNITS

K. Section 23 72 00, AIR-TO-AIR ENERGY RECOVERY EQUIPMENT.

L. Section 23 73 00, INDOOR CENTRAL-STATION AIR-HANDLING UNITS.

N. Section 23 82 00, CONVECTION HEATING AND COOLING UNITS.

**1.3 APPLICABLE PUBLICATIONS**

***Note: From the date contract documents are provided, the Contractor shall use the most current published versions of all listed standards and references below.**

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. The contractor shall use the current editions at time of contract award. Where conflicts occur these specifications and the VHA standards will govern.

B. Air Conditioning and Refrigeration Institute (AHRI):

Directory of Certified Applied Air Conditioning Products

AHRI 4l0.....Forced-Circulation Air-Cooling and Air-Heating Coils

C. American Society for Testing and Materials (ASTM):

B75/75M .....Standard Specifications for Seamless Copper Tube

D. National Electric Manufacturers Association (NEMA):

250 .....Enclosures for Electrical Equipment (1,000 Volts Maximum)

E. National Fire Protection Association (NFPA):

70 .....National Electric Code

F. Underwriters Laboratories, Inc. (UL):

1996 .....Electric Duct Heaters

**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 82 16,AIR COILS”, 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. Submit type, size, arrangements, and performance details. Present application ratings in the form of tables, charts, or curves.

D. Provide installation, operating and maintenance instructions.

E. Certification Compliance: Evidence of listing in current AHRI Directory of Certified Applied Air Conditioning Products.

F. Coils may be submitted with Section 23 36 00, AIR TERMINAL UNITS, Section 23 73 00, or INDOOR CENTRAL-STATION AIR-HANDLING UNITS.

G. 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.

H. 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 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

**1.5 QUALITY ASSURANCE**

A. Refer to paragraph QUALITY ASSURANCE of Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

B. Unless specifically exempted by these specifications, heating and cooling coils shall be tested, rated, and certified in accordance with AHRI 4l0 and shall bear the AHRI certification label.

C. 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.

D. Refer to Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS for additional sustainable design requirements.

**1.6 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 HEATING AND COOLING COILS**

A. Conform to ASTM B75/75M and AHRI 410.

B. Tubes: Minimum 0.625 inch tube diameter; Seamless copper tubing.

C. Fins: 0.0055 inch aluminum or 0.0045 inch copper mechanically bonded or soldered or helically wound around tubing.

D. Headers: Copper, welded steel or cast-iron. Provide seamless copper tubing or resistance welded steel tube for volatile refrigerant coils.

E. "U" Bends, Where Used: Machine die-formed, silver brazed to tube ends.

F. Coil Casing: 1.6 mm (l6 gauge) galvanized steel with tube supports at 1219 mm (48 inch) maximum spacing. Construct casing to eliminate air bypass and moisture carry-over. Provide duct connection flanges.

G. Pressures PSIG:

| Pressure | Water Coil | | Refrigerant Coil |
|---|---|---|---|
| Test | 300 | | 300 |
| Working | 200 | | 250 |

H. Protection: Unless protected by the coil casing, provide cardboard, plywood, or plastic material at the factory to protect tube and finned surfaces during shipping and construction activities.

I. Vents and Drain: Coils that are not vented or drainable by the piping system shall have capped vent/drain connections extended through coil casing.

**2.2 WATER COILS, INCLUDING GLYCOL-WATER**

A. Use the same coil material as listed in paragraph HEATING AND COOLING COILS.

B. Drainable Type (Self-Draining, Self-Venting); Manufacturer Standard:

1. Cooling, all types.
2. Heating or preheat.
3. Runaround energy recovery. AHRI certification of capacity adjustment is waived. See Section 23 72 00, AIR-TO-AIR ENERGY RECOVERY EQUIPMENT.

C. Cleanable Tube Type; Manufacturer Standard:

1. Well water applications.
2. Wastewater applications.

**2.4 VOLATILE REFRIGERANT COILS**

A. Continuous circuit, straight tubes, dry expansion type equipped with multi-port distribution header, less expansion valve.

B. Minimum 16 mm (5/8 inch) tube diameter.

C. Designed for R410A or other EPA approved refrigerants.

**PART 3 - EXECUTION**

**3.1 INSTALLATION**

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. Follow coil manufacturer's instructions for handling, cleaning, installation, and piping connections.

C. Comb fins, if damaged. Eliminate air bypass or leakage at coil sections.

**3.2 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 of 10 working days prior to startup and testing.

**3.3 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.

**3.4 DEMONSTRATION AND TRAINING**

A. Provide services of manufacturer's technical representative for 10 hours to instruct 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 84 00**
**HUMIDITY CONTROL EQUIPMENT**

**PART 1 - GENERAL**

**1.1 DESCRIPTION**

A. A complete listing of common acronyms and abbreviations are included in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

B. This section specifies desiccant dehumidifier units for preconditioning of existing or new air conditioning systems

**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 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.

D. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

E. 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 12, GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION 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.

L. Section 23 21 13, HYDRONIC PIPING.

J. Section 23 22 13, STEAM AND CONDENSATE HEATING PIPING.

K. Section 23 23 00, REFRIGERANT PIPING.

L. Section 23 31 00, HVAC DUCTS AND CASINGS.

M. Section 23 40 00, HVAC AIR CLEANING DEVICES.

N. Section 23 82 16, AIR COILS.

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

P. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

Q. Section 26 29 11, MOTOR CONTROLLERS.

**1.3 APPLICABLE PUBLICATIONS**

***Note: From the date contract documents are provided, the Contractor shall use the most current published versions of all listed standards and references below.**

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. Air-Conditioning, Heating and Refrigeration Institute (AHRI):

410 ..... Forced–Circulation Air-Cooling and Air-Heating Coils

C. Air Movement and Control Association (AMCA):

99 ..... Standards Handbook

210 ..... Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating (ANSI)

300 ..... Reverberant Room Method for Sound Testing of Fans

301 ..... Methods for Calculating Fan Sound Ratings from Laboratory Test Data (ANSI)

D. American Bearing Manufacturers Association (ABMA):

9 ..... Load Ratings and Fatigue Life for Ball Bearings (ANSI)

E. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE):

15 ..... Safety Standard for Refrigeration Systems

34 ..... Designation and Classification of Refrigerants (ANSI)

33 ..... Methods of Testing Forced-Circulation Air-Cooling and Air-Heating Coils (ANSI)

52.2 ..... Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size (ANSI)

62.1 ..... Ventilation for Acceptable Indoor Air Quality (ANSI)

90.1 ..... Energy Standard for Buildings Except Low-Rise Residential Buildings (ANSI)

F. American Society for Testing and Materials (ASTM):

A653/653M ..... Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated by the Hot-Dip Process

B117 ..... Standard Practice for Operating Salt Spray (Fog) Apparatus

C1071 ..... Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)

D1654 ..... Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments

D1735.....Standard Practice for Testing Water Resistance of Coatings Using Water Fog Apparatus

D3359.....Standard Test Methods for Rating Adhesion by Tape Test

D4587.....Standard Practice for Fluorescent UV-Condensation Exposures of Paint and Related Coatings

E84 .....Standard Test Method for Surface Burning Characteristics of Building Materials

G. National Electrical Manufacturers Association (NEMA):

MG 1.....Motors and Generators

H. National Fire Protection Association (NFPA):

70 .....National Electrical Code

90A.....Standard for the Installation of Air-Conditioning and Ventilating Systems

I. Underwriters Laboratories, Inc. (UL):

486A-486B.....Wire Connectors

900 .....Standard for Air Filter Units

J. Department of Veterans Affairs (VA):

PG-18-10 .....HVAC Design Manual

**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 84 00, HUMIDITY CONTROL EQUIPMENT”, 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. Technical data on design operating inlet and outlet conditions, air flows with diagram showing air volumes and conditions throughout the system, dehumidification capacity, filtration and fan motor and electrical power data.
2. A general arrangement diagram with overall dimensions showing all major components with overall dimensions, utility, and duct work connections, bolting arrangement, operating weight and required service and equipment removal clearances.

3. Control diagrams for preconditioning of existing or new air conditioning systems

D. Shop drawings shall indicate assembly, unit dimensions, weight loading, required clearances, construction details, and field connection details.

E. Submit fan curves with specified operating point clearly plotted and sound power levels for both fan outlet and casing radiation at rated capacity.

F. Submit unit control system documentation required for interface with BACnet protocol DDC control system. Submit BACnet compliant Protocol Implementation Conformance Statement (PICS) for all controllers.

G. Submit electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.

H. Certificate: Evidence of satisfactory performance on three similar installations.

I. Performance Test Report: In accordance with PART 3.

J. 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.

K. Completed System Readiness Checklists 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 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

L. 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. Refer to paragraph QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

B. Unit(s) shall be provided by a manufacturer who has been manufacturing desiccant dehumidifiers and have been in satisfactory service for at least three (3) years.

C. Fan Performance Ratings: Conform to AMCA 210 and bear the AMCA Certified Rating Seal.

D. Sound Ratings: AMCA 301; tested to AMCA 300 and bear AMCA Certified Sound Rating Seal.

E. Fabrication: Conform to AMCA 99.

F. Air Coils: Certify capacities, pressure drops, and selection procedures in accordance with AHRI 410.

G. Product of manufacturer regularly engaged in production of pool dehumidification equipment who issues complete catalog data on total product.

H. 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.

I. Refer to Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS for additional sustainable design requirements.

**1.6 DELIVERY, STORAGE, AND 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-fabricated protective containers, with factory-installed shipping skids and lifting lugs. Inspect for damage.

C. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

D. Comply with manufacturer's rigging and installation instructions.

**1.7 PROJECT CONDITIONS**

A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings are lubricated, fan has been test run, all piping is connected and energized, and all wiring is complete and tested.

**1.8 ADDITIONAL REQUIREMENTS**

A. Provide one additional set of fan belts and disposable panel filters for each unit.

B. Corrosion Protection: For air-handling unit mounted coils provide the following corrosion treatment.

1. Epoxy Immersion Coating (Electrically Deposited): The multi-stage corrosion-resistant coating application comprises of cleaning (heated alkaline immersion bath) and reverse-osmosis immersion rinse prior to the start of the coating process. The coating thickness shall be maintained between 0.6-mil and 1.2-mil. Before the coils are subjected to high-temperature oven cure, they are treated to permeate immersion rinse and spray. Where the

coils are subject to UV exposure, UV protection spray treatment comprising of UV-resistant urethane mastic topcoat shall be applied. Provide complete coating process traceability for each coil and minimum five years of limited warranty.

2. The coating process shall such that uniform coating thickness is maintained at the fin edges. The quality control shall be maintained by ensuring compliance to the applicable ASTM Standards for the following:
   a. Salt Spray Resistance (Minimum 6,000 Hours)
   b. Humidity Resistance (Minimum 1,000 Hours)
   c. Water Immersion (Minimum 260 Hours)
   d. Cross-Hatch Adhesion (Minimum 4B-5B Rating)
   e. Impact Resistance (Up to 160 Inch/Pound).
3. Casing Surfaces (Exterior and Interior): All exposed and accessible exterior and interior metal surfaces shall be protected with a water-reducible acrylic with stainless-steel pigment spray-applied over the manufacturer's standard finish. The spray coating thickness shall be 2-4 mils and provide minimum salt-spray resistance of 1,000 hours in accordance with ASTM B117 and 500 hours UV resistance in accordance with ASTM D4587.

**1.9 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 DEHUMIDIFIER UNITS**

A. General: Units shall be complete, factory assembled, and tested; and of sizes, arrangements, capacities, and performance as scheduled and as specified in the schedules shown in the contract documents.
   1. Packaged factory-assembled and factory-tested, refrigerant type, mechanical dehumidification units designed for outdoor installations.
   2. Dehumidification shall be accomplished by use of a desiccant to absorb water vapor and maintain humidity control level independent of load variations within design limit.
   3. Unit(s) shall be capable and designed for year-round, 24-hours-a-day operation; and requiring only connections of ducts, utilities, and remote sensors, controllers, and monitors.
   4. Unit(s) shall include active regeneration system for control of dehumidification processes.

B. Casing:

1. Double-wall construction hinged access doors with neoprene gaskets, minimum 50-mm (2-inch) thick thermal insulation fill, stainless-steel fasteners, knockouts for electrical and piping connections through the side of the unit, condensate drain connection, and lifting lugs.
2. The unit housing the internal partitions shall be constructed of minimum 18 gauge galvanized steel or aluminum pre-insulated double wall panels with a minimum of 50 mm (2 inch) thermal insulation. The base shall be all welded, structural steel or formed 14 gauge, galvanized steel. Units shall have cross supports for each major component and base channels and lifting eyes to facilitate rigging. The units shall be of water and air tight construction over all with interior air tight construction between various sections of the units. Adjoining panels shall be sealed with a silicon compound or heavy-duty compression type gaskets. Leakage rate shall not exceed 2 percent at a pressure of 750 Pa (3.0 inches WG).
3. All non-pre-insulated exterior panels shall be insulated with minimum 25 mm (1 inch) vinyl- or foil-faced fiberglass insulation without exposed edges and secured by permanent mechanical fasteners.
4. All exterior panels shall be constructed with corrosion-protective coating on the manufacturer's standard coating.
5. All internal air-processing and air-treatment components shall be removable through removable access panels without dismantling plenums or ductwork.
6. Access panels shall be provided with resilient gaskets and quick-release hardware.
7. Access doors for filters and control adjustment shall have corrosion-resistant, continuous hinge or heavy-duty, multiple hinges.
8. Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Dehumidifier:

1. The dehumidifier shall include a desiccant wheel utilizing a fractional horsepower electric motor and a variable speed drive and reactivation air flow indicating devices electric and necessary manual and automatic dampers for proper functioning of the unit under all operating conditions.
2. Dehumidifier shall rotary type, designed for continuous operation, and arranged to provide a counter flow of process and reactivation air streams with full-face pressure seals or low-

friction contact seals on both sides to prevent cross leakage for external static pressure of up to 622 Pa (2-1/2 inches WG)

3. Desiccant rotor shall have synthesized silica gel, enhanced with titanium, bonded to a ceramic matrix, with filled voids and encapsulating the ceramic. Driver shall be a motor with adjustable drive sheaves and belt-tensioning idler pulley or adjustable motor mount.
4. The rotary desiccant shall transfer water in the vapor phase. The design and geometry shall provide for laminar flow over the operating range for minimum pressure loss with maximum transfer surface and minimum power requirements. The desiccant shall be a permanent integral part of the structure.

D. Heat Exchanger:

1. The heat exchanger shall be constructed of non-hygroscopic material with corrosion protection, described above for the coils and surfaces thermal wheel to prevent the transfer of water vapor or an air-to-air heat pipe with copper tubes and aluminum fins, fabricated with capillary wick structure charged with ozone friendly refrigerant to be used in the process and reactivation air steams. Refrigerant shall comply with ASHRAE 15, Group 1. For thermal wheel, supply and cooling air streams shall be counter flow and the component provided with full face contact seals on both sides to prevent leakage. The heat transfer effectiveness of the heat exchanger shall be minimum 80 percent with a maximum air pressure loss of 125 Pa (0.50 inch WG)
2. Electric motor shall be fractional-horsepower with close-coupled speed reducer and a belt drive with belt tensioning system for the thermal wheel.

E. Controls and Wiring: Factory-installed microprocessor type to control and monitor unit and communicate to central-control processor and shall operate dehumidification units and maintain humidity and temperature set points. The controller shall be connected to the building DDC control system via an open protocol BACnet interface.

1. The unit shall have a factory wired and unit mounted central, electrical control panel with a single power supply connection. All internal wiring shall be in accordance with the National Electrical Code. Unit shall have a non-fused main power disconnect and control components required for automatic operation based on signals from space mountedduct mounted humidity and temperature controls. Control panel shall have terminals for remote control devices.

2. Controls shall be capable of shutting down the dehumidifier when humidity loads are reduced, and the process shall be reversed when there is an increase in humidity loads.
3. Reactivation energy shall be automatically reduced at lower than design humidity loads.
4. Carbon dioxide sensor mounted in return air shall operate minimum outdoor-air damper position.
5. Discharge-air, outdoor-air, conditioned-space, control set-point-temperature, and outdoor-air enthalpy shall be displayed with a LCD in control panel.
6. Filter pressure drop, and alarm shall be displayed by an LCD in control panel.
7. Airflow, fans, system, unit operation, and operating mode status shall be displayed in control panel.

F. Housed Centrifugal Fan Sections:
1. Supply fans, shall be centrifugal, galvanized steel with power coated finish, and shall be belt driven with adjustable sheaves and self-aligning, grease-lubricated ball bearings with extended grease fittings easily accessible inside the casing for process and reactivation air as scheduled.
2. Fans shall be AMCA class II construction, double-width, and double-inlet centrifugal air foil or backward inclined or plenum type, factory dynamically balanced and rated in accordance with AMCA 210.
3. Fan sized for greater than 3000 CFM shall be belt driven. Belts shall be sized for 150 percent of fan motor HP.
4. Fans shall be vibration isolated internally or externally.
5. Connections at fan discharge shall have flexible duct connectors.
6. Fan motor and Drive: Motors shall be nominal 1750 RPM. Motor for reactivation fan may be direct-drive 3500 RPM. Motors shall be NEMA MG 1 Design B with open drip-proof housing and a minimum service factor of 1.15 complying with requirements in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
7. Plenum Fans Single and/or Multiple Fans in an Array: Fans shall be Class II (minimum) construction with single inlet, aluminum wheel and stamped air-foil aluminum blades. The fan wheel shall be mounted on the directly-driven motor shaft in AMCA Arrangement 4.

G. Filter Section: Pleated, disposable pre-filters in return-air mixing plenums. Filters shall be 50 mm (2 inches) thick, installed in filter rack, with a minimum efficiency report value (MERV) of 7 according to ASHRAE 52.2 and 90 percent average arrestance.

H. Reactivation Heating Coil :
   1. Electric-resistance heating coil to supply supplemental heating to the space during winter. Refer to Section 23 82 16, AIR COILS for requirements.

I. Post Cooling Coil Section: Comply with requirements in Section 23 82 16, AIR COILS.

J. Refrigeration Package: Comply with ASHRAE 15.
   1. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IESNA 90.1.
   2. Refrigerant Coils: Copper tubes with mechanically bonded aluminum fins; factory-fabricated and tested according to ASHRAE 33 and AHRI 410; with multiple refrigerant circuits, seamless-copper headers with brazed connections, and galvanized-steelstainless-steel frame. Coil and fins shall have a polyester coating. Coils shall have a minimum 2070 kPa (300 psig) working-pressure rating and be factory tested to 3102 kPa (450 psig), and to 2070 kPa (300 psig) while underwater.
   3. Compressors: Hermetic compressors with integral vibration isolators and crankcase heaters that de-energize during compressor operation; with thermal-expansion valves, filter-dryers, sight glasses, compressor service valves, and liquid- and suction-line service valves.
   4. Number of Refrigerant Circuits: Two for compressor capacities greater than 7-1/2 tons.
   5. Refrigerant: Use refrigerant type R410A. EPA approved refrigerants are listed at https://www.epa.gov/snap/. Submit proposed refrigerant for government approval.
   6. Capacity Control: Hot-gas bypass valve and piping on one compressor.

K. Safety Devices:
   1. Low-Pressure Cutout: Manual reset after three auto-reset failures.
   2. High-Pressure Cutout: Manual reset.
   3. Compressor Motor Overload Protection: Manual reset.
   4. Antirecycling Timing Device: Prevent compressor restart for five minutes after shutdown.
   5. Adjustable, Low-Ambient, Head-Pressure Control: Designed to operate at temperatures as low as -18 degrees C (0 degrees F) by cycling condenser fans and controlling speed of last fan of each circuit.
   6. Oil-Pressure Switch: Designed to shut down compressors on low oil pressure.

L. Condenser Fans: Propeller-type fans directly driven by motors with permanently lubricated bearings and internal thermal-overload protection.

M. Drain Pan and Connection: Plastic; insulated and complying with ASHRAE 62.1.

N. Remote-control panel shall contain controls and indicator lights consisting of the following:

1. On-off fan switch.
2. Minimum outdoor-air damper potentiometer position LCD.
3. Supply-fan operating indicator light.
4. Mechanical cooling malfunction indicator light.
5. Clogged filter indicator light.

O. Electrical Convenience Outlet: 120-V ac fused, duplex straight-blade receptacles separately fused and located inside dehumidification unit casing.

**PART 3 – EXECUTION**

**3.1 INSTALLATION**

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. Follow equipment manufacturer's written instructions for handling and installation of equipment.

C. Adjust seals and purge of rotating wheels as recommended by the manufacturer.

D. Verify correct settings and installation of controls.

E. Install seismic restraints for equipment in seismic areas as required under Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

F. Isolation Curb Support: Install dehumidification units on isolation curbs, and install flexible duct connectors and vibration isolation and seismic-control devices. Flexible duct connectors are specified in Section 23 31 00, HVAC DUCTS AND CASINGS. Vibration isolation and seismic-control devices are specified in Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.

**3.2 CONNECTIONS**

A. Install piping adjacent to machine to allow service and maintenance.

B. Connect piping to dehumidification units mounted on vibration isolators with flexible connectors.

C. Connect condensate drain pans using minimum DN 32 (NPS 1-1/4 inches) copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install clean out at changes in direction.

D. Refrigerant Piping: Comply with applicable requirements in Section 23 23 00, REFRIGERANT PIPING. Connect to supply and return coil tappings with shutoff valve and union or flange at each connection.

E. Ground equipment according to Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.

F. Connect wiring according to Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES.

G. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

**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.

D. Perform the following final checks before startup:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connection to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Perform cleaning and adjusting specified in this Section.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify free fan wheel rotation and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
5. Verify lubrication of bearings, pulleys, belts, and other moving parts.
6. Set outside- and return-air mixing dampers to minimum outdoor-air setting.
7. Install clean filters.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

E. Perform the following starting procedures for dehumidification units:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace malfunctioning motors, bearings, and fan wheels.
2. Measure and record motor electrical values for voltage and amperage.
3. Manually operate dampers from fully closed to fully open position and record fan performance.

F. Complete installation and startup check according to manufacturer's written instructions.

G. Startup Report: Report findings during startup. Identify startup steps, corrective measures taken and final results.

**3.4 ADJUSTING**

A. Adjust damper linkages for proper damper operation.

B. Adjust initial temperature and humidity set points.

**3.5 CLEANING**

A. Clean dehumidification units internally, on completion of installation, according to manufacturer's written instructions. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils' entering-air face.

B. After completing system installation, testing, and startup service of dehumidification units, clean filter housings and install new filters.

**3.6 INSTRUCTIONS**

A. Provide services of manufacturer’s technical representative for eight hours to instruct VA personnel in operation and maintenance of desiccant dehumidifiers.

**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 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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