

100% BID DOCUMENTS

SPECIFICATIONS

BUILDING 500, AC-19 REPLACEMENT VA PROJECT NO. 613-12-107
BUILDING 500, AC-20 REPLACEMENT VA PROJECT NO. 613-15-300
BLDG 500, INTERSTITIAL HVAC UPGRADE VA PROJECT NO. 613-15-312



Martinsburg VA Medical Center
Martinsburg, WV

Volume II

Miller-Remick LLC
1010 Kings Highway South
Building Two – 2nd Floor
Cherry Hill, New Jersey 08034

July 8, 2016



Miller-Remick LLC
M.E.P. & Structural Engineering
A Service Disabled Veteran Owned Small Business



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 Building 500, AC-20 Replacement
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**DEPARTMENT OF VETERANS AFFAIRS
 VHA MASTER SPECIFICATIONS**

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SECTION 00 01 15
LIST OF DRAWINGS

The drawings listed below accompanying this specification form a part of the contract.

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MD114 MECHANICAL DEMOLITION-PIPE CHASE & PERIMETER HEATING

MD115 MECHANICAL DEMOLITION -SEVENTH FL M.E.R DUCTWORK PLAN NORTH

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MD117 MECHANICAL DEMOLITION -SEVENTH FL M.E.R PIPING PLAN NORTH

MD118 MECHANICAL DEMOLITION -SEVENTH FL M.E.R PIPING PLAN SOUTH

MD119 MECHANICAL DEMOLITION-SEVENTH FL ELEVATOR MACHINE RM PLAN

MD120 MECHANICAL DEMOLITION- ROOF DUCTWORK PLAN

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MH103 MECHANICAL-BASEMENT INTERSTITIAL SPACE PLAN - AREA C

MH104 MECHANICAL-BASEMENT INTERSTITIAL SPACE PLAN - AREA D

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ED103 ELECTRICAL DEMOLITION BASEMENT INTERSTITIAL SPACE PLAN - C
ED104 ELECTRICAL DEMOLITION BASEMENT INTERSTITIAL SPACE PLAN - D
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ED113 ELECTRICAL DEMOLITION PENTHOUSE PLAN
ED114 ELECTRICAL DEMOLITION ELEVATOR MACHINE ROOM PLAN
ED115 ELECTRICAL DEMOLITION ROOFTOP POWER PLAN - 5C NORTH
ED501 ELECTRICAL DEMOLITION MCC SINGLE LINE DIAGRAM
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E-105 ELECTRICAL FIRST FLOOR INTERSTITIAL SPACE PLAN - A
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E-502 ELECTRICAL DEMOLITION & NEW - PARTIAL RISER DIAGRAMS
E-503 ELECTRICAL DETAILS
E-601 ELECTRICAL SCHEDULES
E-602 ELECTRICAL/MECHANICAL COORDINATION SCHEDULES

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SECTION 21 13 13
WET-PIPE SPRINKLER SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Design, installation and testing shall be in accordance with NFPA 13.
- B. The design and installation of a hydraulically calculated automatic wet-pipe system complete and ready for operation, for all renovated portions of Building 500, including the penthouse, and elevator machine rooms.
- C. 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.
- C. Section 09 91 00, PAINTING.
- D. 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:

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- a. Ordinary Hazard Group 1 Occupancies: Mechanical Equipment Rooms, Electric Closets, and Elevator Machine rooms.
 - b. Ordinary Hazard Group 2 Occupancies: Storage rooms, building management storage.
3. Hydraulic Calculations: Calculated demand including hose stream requirements shall fall no less than 10 percent below the available water supply curve.
4. Water Supply: Base water supply on existing fire pump flow test (see VAMC Martinsburg WV for current pump test data).
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

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compact disc or as directed by the Contracting Officer's Representative (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.

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

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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. 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, 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 West Virginia 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

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equipment shall be new unless specifically indicated otherwise on the contract drawings.

1.6 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. National Fire Protection Association (NFPA):
- 13-13.....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 (2015)
- 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.
 - 4. Plastic piping shall not be permitted except for drain piping.
 - 5. 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.

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2. Do not use quarter turn ball valves for 50 mm (2 inch) or larger drain valves.

2.3 SPRINKLERS

- A. Provide FM approved quick response sprinklers in all areas, except that standard response sprinklers shall be provided in elevator hoistways, elevator machine rooms, and generator rooms.
- 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 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 CABINET

- A. Provide sprinkler cabinet with the required number of sprinkler heads of all ratings and types installed, and a sprinkler wrench for each type of sprinkler in accordance with NFPA 13. Locate adjacent to the riser.
- B. Provide a list of sprinklers installed in the property in the cabinet. The list shall include the following:
 1. Manufacturer, model, orifice, deflector type, thermal sensitivity, and pressure for each type of sprinkler in the cabinet.
 2. General description of where each sprinkler is used.
 3. Quantity of each type present in the cabinet.
 4. Issue or revision date of list.

2.5 PIPE HANGERS, SUPPORTS AND RESTRAINT OF SYSTEM PIPING

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

2.6 WALL, FLOOR AND CEILING PLATES

Provide chrome plated steel escutcheon plates.

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, 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, 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. 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.
- F. Provide escutcheon plates for exposed piping passing through walls, floors or ceilings.
- G. 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

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(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.

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

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- a. 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.
- S. 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.
- T. 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 presence of the COR or 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

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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 22 05 11
COMMON WORK RESULTS FOR PLUMBING**

PART 1 - GENERAL

1.1 DESCRIPTION

- A. The requirements of this Section shall apply to all sections of Division 22.
- B. Definitions:
 - 1. Exposed: Piping and equipment exposed to view in finished rooms.
- C. Abbreviations/Acronyms:
 - 1. ABS: Acrylonitrile Butadiene Styrene
 - 2. AISI: American Iron and Steel Institute
 - 3. AWG: American Wire Gauge
 - 4. BACnet: Building Automation and Control Network
 - 5. BSG: Borosilicate Glass Pipe
 - 6. CDA: Copper Development Association
 - 7. CO: Carbon Monoxide
 - 8. COR: Contracting Officer's Representative
 - 9. CPVC: Chlorinated Polyvinyl Chloride
 - 10. CR: Chloroprene
 - 11. CWP: Cold Working Pressure
 - 12. db(A): Decibels (A weighted)
 - 13. DDC: Direct Digital Control
 - 14. DISS: Diameter Index Safety System
 - 15. DWV: Drainage, Waste and Vent
 - 16. ECC: Engineering Control Center
 - 17. EPDM: Ethylene Propylene Diene Monomer
 - 18. EPT: Ethylene Propylene Terpolymer
 - 19. ETO: Ethylene Oxide
 - 20. FAR: Federal Acquisition Regulations
 - 21. FD: Floor Drain
 - 22. FG: Fiberglass
 - 23. FNPT: Female National Pipe Thread
 - 24. FPM: Fluoroelastomer Polymer
 - 25. HDPE: High Density Polyethylene

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- 26. HOA: Hands-Off-Automatic
- 27. HP: Horsepower
- 28. ID: Inside Diameter
- 29. MAWP: Maximum Allowable Working Pressure
- 30. NPTF: National Pipe Thread Female
- 31. NPS: Nominal Pipe Size
- 32. NPT: National Pipe Thread
- 33. OD: Outside Diameter
- 34. OSD: Open Sight Drain
- 35. OS&Y: Outside Stem and Yoke
- 36. PP: Polypropylene
- 37. PTFE: Polytetrafluoroethylene
- 38. PVC: Polyvinyl Chloride
- 39. PVDF: Polyvinylidene Fluoride
- 40. RTRP: Reinforced Thermosetting Resin Pipe
- 41. SPS: Sterile Processing Services
- 42. SUS: Saybolt Universal Second
- 43. SWP: Steam Working Pressure
- 44. TFE: Tetrafluoroethylene
- 45. THHN: Thermoplastic High-Heat Resistant Nylon Coated Wire
- 46. THWN: Thermoplastic Heat & Water Resistant Nylon Coated Wire
- 47. USDA: U.S. Department of Agriculture
- 48. VAC: Voltage in Alternating Current
- 49. WOG: Water, Oil, Gas

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 50 00, METAL FABRICATIONS.
- G. Section 07 60 00, FLASHING AND SHEET METAL: Flashing for Wall and Roof Penetrations.
- H. Section 07 84 00, FIRESTOPPING.
- I. Section 07 92 00, JOINT SEALANTS.

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- J. Section 09 91 00, PAINTING.
- K. Section 22 05 12, GENERAL MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT.
- L. Section 22 07 11, PLUMBING INSULATION.
- M. Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.
- N. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
- O. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- P. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES.
- Q. Section 26 29 11, MOTOR CONTROLLERS.

1.3 APPLICABLE PUBLICATIONS

- A. The publications listed below shall form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American Society of Mechanical Engineers (ASME):
 - ASME Boiler and Pressure Vessel Code -
 - BPVC Section IX-2013....Welding, Brazing, and Fusing Qualifications
 - B31.1-2012.....Power Piping
- C. American Society for Testing and Materials (ASTM):
 - A36/A36M-2012.....Standard Specification for Carbon Structural Steel
 - A575-96(R2013)e1.....Standard Specification for Steel Bars, Carbon, Merchant Quality, M-Grades
 - E84-2013a.....Standard Test Method for Surface Burning Characteristics of Building Materials
 - E119-2012a.....Standard Test Methods for Fire Tests of Building Construction and Materials
- D. International Code Council, (ICC):
 - IBC-2012.....International Building Code
 - IPC-2012.....International Plumbing Code
- E. Manufacturers Standardization Society (MSS) of the Valve and Fittings Industry, Inc:
 - SP-58-2009.....Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application and Installation
 - SP-69-2003.....Pipe Hangers and Supports - Selection and Application

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F. Military Specifications (MIL):

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

G. National Electrical Manufacturers Association (NEMA):

MG 1-2011.....Motors and Generators

H. National Fire Protection Association (NFPA):

51B-2014.....Standard for Fire Prevention During Welding,
Cutting and Other Hot Work

54-2012.....National Fuel Gas Code

70-2014.....National Electrical Code (NEC)

I. NSF International (NSF):

5-2012.....Water Heaters, Hot Water Supply Boilers, and
Heat Recovery Equipment

14-2012.....Plastic Piping System Components and Related
Materials

61-2012.....Drinking Water System Components - Health
Effects

372-2011.....Drinking Water System Components - Lead Content

J. Department of Veterans Affairs (VA):

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

PG-18-13-2011.....Barrier Free Design Guide

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 11, COMMON WORK RESULTS FOR PLUMBING", 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 will fit the space available.
- D. If equipment is submitted which differs in arrangement from that shown, provide drawings that show the rearrangement of all associated systems. Approval will be given only if all features of the equipment and

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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 drawings and specifications, and have jointly coordinated and properly integrated their equipment and controls to provide a complete and efficient installation.
- F. Installing Contractor shall provide lists of previous installations for selected items of equipment. Contact persons who will serve as references, with telephone numbers and e-mail addresses shall be submitted with the references.
- G. Manufacturer's Literature and Data: Manufacturer's literature shall be submitted under the pertinent section rather than under this section.
 - 1. Electric motor data and variable speed drive data shall be submitted with the driven equipment.
 - 2. Equipment and materials identification.
 - 3. Firestopping materials.
 - 4. Hangers, inserts, supports and bracing. Provide load calculations for variable spring and constant support hangers.
 - 5. Wall, floor, and ceiling plates.
- H. Submittals and shop drawings for interdependent items, containing applicable descriptive information, shall be furnished together and complete in a group. Coordinate and properly integrate materials and equipment in each group to provide a completely compatible and efficient installation. Final review and approvals will be made only by groups.
- I. Coordination Drawings: Complete consolidated and coordinated layout drawings shall be submitted for all new systems, and for existing systems that are in the same areas. The 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 the proposed location and adequate clearance for all equipment, controls, piping, pumps, valves and other items. All valves, trap primer valves, water hammer

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arrestors, strainers, and equipment requiring service shall be provided with an access door sized for the complete removal of plumbing device, component, or equipment. Equipment foundations shall not be installed until equipment or piping layout drawings have been approved. Detailed layout drawings shall be provided for all piping systems. In addition, details of the following shall be provided.

1. Mechanical equipment rooms.
2. Hangers, inserts, supports, and bracing.
3. Pipe sleeves.
4. Equipment penetrations of floors, walls, ceilings, or roofs.

J. Maintenance Data and Operating Instructions:

1. Maintenance and operating manuals in accordance with Section 01 00 00, GENERAL REQUIREMENTS, Article, INSTRUCTIONS, for systems and equipment. Include complete list indicating all components of the systems with diagrams of the internal wiring for each item of equipment.
2. Include listing of recommended replacement parts for keeping in stock supply, including sources of supply, for equipment shall be provided. The listing shall include belts for equipment: Belt manufacturer, model number, size and style, and distinguished whether of multiple belt sets.

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

1.5 QUALITY ASSURANCE

A. Products Criteria:

1. Standard Products: Material and equipment shall 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, shall be the current generation of technology and basic design that has a proven satisfactory service record of at least 5 years.

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2. Equipment Service: There shall be permanent service organizations, authorized and trained by manufacturers of the equipment supplied, located within 160 km (100 miles) of the project. These organizations shall come to the site and provide acceptable service to restore operations within four 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 shall be submitted for project record and inserted into the operations and maintenance manual.
3. All items furnished shall be free from defects that would adversely affect the performance, maintainability and appearance of individual components and overall assembly.
4. The products and execution of work specified in Division 22 shall conform to the referenced codes and standards as required by the specifications. Local codes and amendments enforced by the local code official shall be enforced, if required by local authorities such as the natural gas supplier. If the local codes are more stringent, then the local code shall apply. Any conflicts shall be brought to attention of 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 shall be products of one manufacturer.
6. Assembled Units: Manufacturers of equipment assemblies, which use components made by others, assume complete responsibility for the final assembled product.
7. Nameplates: Nameplate bearing manufacturer's name or identifiable trademark shall be securely affixed in a conspicuous place on 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 shall not be used.

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9. 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. Welding: Before any welding is performed, contractor shall submit a certificate certifying that welders comply with the following requirements:
 1. Qualify welding processes and operators for piping according to ASME "Boiler and Pressure Vessel Code", Section IX, "Welding and Brazing Qualifications".
 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 American Welding Society.
- C. Manufacturer's Recommendations: Where installation procedures or any part thereof are required to be in accordance with the recommendations of the manufacturer of the material being installed, printed copies of these recommendations shall be furnished to the COR prior to installation. Installation of the item will not be allowed to proceed until the recommendations are received. Failure to furnish these recommendations can be cause for rejection of the material.
- D. Execution (Installation, Construction) Quality:
 1. All items shall be applied and installed in accordance with manufacturer's written instructions. Conflicts between the manufacturer's instructions and the contract documents shall be referred to the COR for resolution. Printed copies or electronic files of manufacturer's installation instructions shall be provided to the COR at least 10 working days prior to commencing installation of any item.

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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, and control devices. Prior to commencing installation work, refer conflicts between this requirement and contract documents to COR for resolution.
 3. Complete layout drawings shall be required by Paragraph, SUBMITTALS. Construction work shall not start on any system until the layout drawings have been approved by VA.
 4. Installer Qualifications: Installer shall be licensed and shall provide evidence of the successful completion of at least five projects of equal or greater size and complexity. Provide tradesmen skilled in the appropriate trade.
 5. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no additional cost or additional time to the Government.
- E. Guaranty: Warranty of Construction, FAR clause 52.246-21.
- F. Plumbing Systems: IPC, International Plumbing Code. Unless otherwise required herein, perform plumbing work in accordance with the latest version of the IPC. For IPC codes referenced in the contract documents, advisory provisions shall be considered mandatory, the word "should" shall be interpreted as "shall". Reference to the "code official" or "owner" shall be interpreted to mean the COR.
- G. Cleanliness of Piping and Equipment Systems:
1. Care shall be exercised in the storage and handling of equipment and piping material to be incorporated in the work. Debris arising from cutting, threading and welding of piping shall be removed.
 2. Piping systems shall be flushed, blown or pigged as necessary to deliver clean systems.
 3. The interior of all tanks shall be cleaned prior to delivery and beneficial use by the Government. All piping shall be tested in accordance with the specifications and the International Plumbing

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

4. Contractor shall 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 shall remain in the custody of the Contractor until phased acceptance, whether or not the Government has reimbursed the Contractor for the equipment and material. The Contractor is solely responsible for the protection of such equipment and material against any damage.
2. Damaged equipment shall be replaced with an identical unit as determined and directed by the COR. Such replacement shall be at no additional cost or additional time to the Government.
3. Interiors of new equipment and piping systems shall be protected against entry of foreign matter. Both inside and outside shall be cleaned before painting or placing equipment in operation.
4. Existing equipment and piping being worked on by the Contractor shall be under the custody and responsibility of the Contractor and shall be protected as required for new work.

1.7 AS-BUILT DOCUMENTATION

- A. Submit manufacturer's literature and data updated to include submittal review comments and any equipment substitutions.
- B. Submit operation and maintenance data updated to include submittal review comments, substitutions and construction revisions shall be 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.

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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 on Auto-Cad version 2012 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 a certification that all results of tests were within limits specified.

PART 2 - PRODUCTS

2.1 MATERIALS FOR VARIOUS SERVICES

- A. Steel pipe shall contain a minimum of 25 percent recycled content.
- B. Solder or flux containing lead shall not be used with copper pipe.
- C. Material or equipment containing a weighted average of greater than 0.25 percent lead shall not be used in any potable water system intended for human consumption, and shall be certified in accordance with NSF 61 or NSF 372.
- D. In-line devices such as water meters, building valves, check valves, stops, valves, fittings, tanks and backflow preventers shall comply with NSF 61 and NSF 372.
- E. End point devices such as end-point control valves used to dispense drinking water must meet requirements of NSF 61 and NSF 372.

2.2 FACTORY-ASSEMBLED PRODUCTS

- A. Standardization of components shall be maximized to reduce spare part requirements.
- B. Manufacturers of equipment assemblies that include components made by others shall assume complete responsibility for final assembled unit.
 - 1. All components of an assembled unit need not be products of same manufacturer.

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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 at no additional cost or time to the Government.
- C. Components of equipment shall bear manufacturer's name and trademark, model number, serial number and performance data on a name plate securely affixed in a conspicuous place, or cast integral with, stamped or otherwise permanently marked upon the components of the equipment.
- D. Major items of equipment, which serve the same function, shall be the same make and model.

2.3 COMPATIBILITY OF RELATED EQUIPMENT

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

2.4 SAFETY GUARDS

- A. Pump shafts and couplings shall be fully guarded by a sheet steel guard, covering coupling and shaft but not bearings. Material shall be minimum 16-gage sheet steel; ends shall be braked and drilled and attached to pump base with minimum of four 8 mm (1/4 inch) bolts. Reinforce guard as necessary to prevent side play forcing guard onto couplings.
- B. All Equipment shall have moving parts protected from personal injury.

2.5 LIFTING ATTACHMENTS

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

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2.6 ELECTRIC MOTORS, MOTOR CONTROL, CONTROL WIRING

- A. All material and equipment furnished and installation methods used shall 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 shall be provided. Premium efficient motors shall be provided. Unless otherwise specified for a particular application, electric motors shall have the following requirements.
- B. 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, and 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° C (160° F) shall 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, shall be NFPA 70 designation THWN.
 - c. Shielded conductors or wiring in separate conduits for all instrumentation and control systems shall be provided where recommended by manufacturer of equipment.
 4. Motor sizes shall be selected so that the motors do not operate into the service factor at maximum required loads on the driven equipment. Motors on pumps shall be sized for non-overloading at all points on the pump performance curves.
 5. Motors utilized with variable frequency drives shall be rated "inverter-ready" per NEMA Standard, MG1.

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- C. Motor Efficiency and Power Factor: All motors, when specified as "high efficiency or Premium Efficiency" by the project specifications on driven equipment, shall 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". Motors not specified as "high efficiency or premium efficiency" shall comply with the requirements of the Energy Policy and Conservation Act.
- D. Single-phase Motors: Capacitor-start type for hard starting applications. Motors for centrifugal pumps may be split phase or permanent split capacitor (PSC).
- E. Poly-phase Motors: NEMA Design B, Squirrel cage, induction type. Each two-speed motor shall have two separate windings. A time delay (20 seconds minimum) relay shall be provided for switching from high to low speed.
- F. Rating: Rating shall 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 shall not exceed nameplate rating without service factor.
- G. Insulation Resistance: Not less than one-half meg-ohm between stator conductors and frame shall be measured at the time of final inspection.

2.7 EQUIPMENT AND MATERIALS IDENTIFICATION

- A. Use symbols, nomenclature and equipment numbers specified, shown on the drawings, or shown in the maintenance manuals. Coordinate equipment and valve identification with facility maintenance staff. 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 shall be permanently fastened to the equipment. Unit components such as water heaters, tanks, coils, filters, etc. shall be identified.

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- C. Control Items: All temperature, pressure, and controllers shall be labeled and the component's function identified. Identify and label each item as they appear on the control diagrams.
- D. Valve Tags and Lists:
1. Plumbing: All valves shall be provided with valve tags and listed on a valve list (Fixture stops not included).
 2. Valve tags: Engraved black filled numbers and letters not less than 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 or brass chain.
 3. Valve lists: Valve lists shall be created using a word processing program and printed on plastic coated cards. The plastic coated valve list card(s), sized 215 mm (8-1/2 inches) by 275 mm (11 inches) shall show valve tag number, valve function and area of control for each service or system. The valve list shall be in a punched 3-ring binder notebook. An additional copy of the valve list shall be mounted in picture frames for mounting to a wall. COR shall instruct contractor where frames shall be mounted.
 4. A detailed plan for each floor of the building indicating the location and valve number for each valve shall be provided in the 3-ring binder notebook. Each valve location shall be identified with a color coded sticker or thumb tack in ceiling or access door.

2.8 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.

2.9 GALVANIZED REPAIR COMPOUND

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

2.10 PIPE AND EQUIPMENT SUPPORTS AND RESTRAINTS

- A. In lieu of the paragraph which follows, suspended equipment support and restraints may be designed and installed in accordance with the International Building Code (IBC). Submittals based on the International Building Code (IBC) requirements, or the following paragraphs of this Section shall be stamped and signed by a

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professional engineer registered in the state where the project is located. The Support system of suspended equipment over 227 kg (500 pounds) shall be submitted for approval of the COR in all cases. See the above specifications for lateral force design requirements.

- B. Type Numbers Specified: For materials, design, manufacture, selection, application, and installation refer to MSS SP-58. For selection and application refer to MSS SP-69. Refer to Section 05 50 00, METAL FABRICATIONS, for miscellaneous metal support materials and prime coat painting.
- C. 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.
- D. 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.
- 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 shall 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 gage), 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 shall 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.

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- 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 gage) minimum.

2.11 PIPE PENETRATIONS

- A. Pipe penetration sleeves shall be installed for all pipe other than rectangular blocked out floor openings for risers in mechanical bays.
- B. Pipe penetration sleeve materials shall comply with all 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 50 mm (2 inch) above finished floor and provide sealant for watertight joint.
 - 2. For blocked out floor openings: Provide 40 mm (1-1/2 inch) angle set in silicone adhesive around opening.
 - 3. For drilled penetrations: Provide 40 mm (1-1/2 inch) angle ring or square set in silicone adhesive around penetration.
- D. Penetrations are not allowed through beams or ribs, but may be installed in concrete beam flanges, 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 shall be provided for pipe passing through floors, interior walls, and partitions, unless brass or steel pipe sleeves are specifically called for below.
- F. Galvanized steel or an alternate black iron pipe with asphalt coating sleeves shall be for pipe passing through concrete beam flanges, except where brass pipe sleeves are called for. A galvanized steel sleeve shall be provided for pipe passing through floor of mechanical rooms, laundry work rooms, and animal rooms above basement. Except in mechanical rooms, sleeves shall be connected with a floor plate.

- G. Brass Pipe Sleeves shall be provided for pipe passing through quarry tile, terrazzo or ceramic tile floors. The sleeve shall be connected with a floor plate.
- H. Sleeve clearance through floors, walls, partitions, and beam flanges shall be 25 mm (1 inch) greater in diameter than external diameter of pipe. Sleeve for pipe with insulation shall be large enough to accommodate the insulation plus 25 mm (1 inch) in diameter. Interior openings shall be caulked tight with firestopping material and sealant to prevent the spread of fire, smoke, water and gases.
- I. Sealant and Adhesives: Shall be as specified in Section 07 92 00, JOINT SEALANTS. Bio-based materials shall be utilized when possible.

2.12 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 shall be utilized when possible.

2.13 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 shall be used where insulation ends on exposed water supply pipe drop from overhead.

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A watertight joint shall be provided in spaces where brass or steel pipe sleeves are specified.

2.14 ASBESTOS

- A. Materials containing asbestos are not permitted.

PART 3 - EXECUTION

3.1 ARRANGEMENT AND INSTALLATION OF EQUIPMENT AND PIPING

- A. Location of piping, sleeves, inserts, hangers, and equipment, access provisions shall be coordinated with the work of all trades. Piping, sleeves, inserts, hangers, and equipment shall be located clear of windows, doors, openings, light outlets, and other services and utilities. Equipment layout drawings shall be prepared to coordinate proper location and personnel access of all facilities. The drawings shall be submitted for review.
- B. Manufacturer's published recommendations shall be followed for installation methods not otherwise specified.
- C. Operating Personnel Access and Observation Provisions: All equipment and systems shall be arranged to provide clear view and easy access, without use of portable ladders, for maintenance, 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 gages and indicators shall be clearly visible by personnel standing on the floor or on permanent platforms. Maintenance and operating space and access provisions that are shown on the drawings shall not be changed nor reduced.
- D. Structural systems necessary for pipe and equipment support shall be coordinated to permit proper installation.
- E. Location of pipe sleeves, trenches and chases shall be accurately coordinated with equipment and piping locations.
- F. Cutting Holes:
 - 1. Holes shall be located to avoid interference with structural members such as beams or grade beams. Holes shall be laid out in advance and drilling done only after approval by COR. If the Contractor considers it necessary to drill through structural members, this matter shall be referred to COR for approval.

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2. Waterproof membrane shall not be penetrated. Pipe floor penetration block outs shall be provided outside the extents of the waterproof membrane.
 3. Holes through concrete and masonry shall be cut by rotary core drill. Pneumatic hammer, impact electric, and hand or manual hammer type drill will not be allowed, except as permitted by COR where working area space is limited.
- G. Interconnection of Pneumatic Instrumentation and Controls: Generally, pneumatic interconnections are not shown but must be provided.
- H. Minor Piping: Generally, small diameter pipe runs from drips and drains, water cooling, and other service are not shown but must be provided.
- I. 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 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 shall be tightly covered against dirt or mechanical injury. At completion of all work thoroughly clean fixtures, exposed materials and equipment.
- J. Concrete and Grout: Concrete and shrink compensating grout 25 MPa (3000 psig) minimum shall be used for all pad or floor mounted equipment.
- K. Gages, thermometers, valves and other devices shall be installed with due regard for ease in reading or operating and maintaining said devices. Thermometers and gages shall be located and positioned to be easily read by operator or staff standing on floor or walkway provided. Servicing shall not require dismantling adjacent equipment or pipe work.

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- L. Interconnection of Electrical Instrumentation and Controls: Electrical interconnection is generally not shown but shall be provided. This includes interconnections of sensors, transmitters, transducers, control devices, control and instrumentation panels, alarms, instruments and computer workstations. Comply with NFPA 70.
- M. Many plumbing systems interface with the HVAC control system. See the HVAC control points list and Section 23 09 23, DIRECT DIGITAL CONTROL SYSTEM FOR HVAC.
- N. 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.
- O. Work in bathrooms, restrooms, housekeeping closets: All pipe penetrations behind escutcheons shall be sealed with plumbers putty.
- P. Switchgear Drip Protection: Every effort shall 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 shall be provided in low point of casement pipe.
- Q. Inaccessible Equipment:
 - 1. Where the Government determines that the Contractor has installed equipment not conveniently accessible for operation and maintenance, equipment shall be removed and reinstalled or remedial action performed as directed at no additional cost 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.

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3.2 TEMPORARY PIPING AND EQUIPMENT

- A. Continuity of operation of existing facilities may require temporary installation or relocation of equipment and piping. Temporary equipment or pipe installation or relocation shall be provided to maintain continuity of operation of existing facilities.
- B. The Contractor shall provide all required facilities in accordance with the requirements of phased construction and maintenance of service. All piping and equipment shall be properly supported, sloped to drain, operate without excessive stress, and shall be insulated where injury can occur to personnel by contact with operating facilities. The requirements of paragraph 3.1 shall apply.
- C. Temporary facilities and piping shall be completely removed back to the nearest active distribution branch or main pipe line and any openings in structures sealed. Dead legs are not allowed in potable water systems. Necessary blind flanges and caps shall be provided to seal open piping remaining in service.

3.3 RIGGING

- A. Openings in building structures shall be planned to accommodate design scheme.
- B. Alternative methods of equipment delivery may be offered and will be considered by Government under specified restrictions of phasing and service requirements as well as structural integrity of the building.
- C. All openings in the building shall be closed when not required for rigging operations to maintain proper environment in the facility for Government operation and maintenance of service.
- D. Contractor shall provide all facilities required to deliver specified equipment and place on foundations. Attachments to structures for rigging purposes and support of equipment on structures shall be Contractor's full responsibility.
- E. Contractor shall check all clearances, weight limitations and shall provide a rigging plan designed by a Registered Professional Engineer. All modifications to structures, including reinforcement thereof, shall be at Contractor's cost, time and responsibility.
- F. Rigging plan and methods shall be referred to COR for evaluation prior to actual work.

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3.4 PIPE AND EQUIPMENT SUPPORTS

- A. Where hanger spacing does not correspond with joist or rib spacing, use structural steel channels secured directly to joist and rib structure that will correspond to the required hanger spacing, and then suspend the equipment and piping from the channels. Holes shall be drilled or burned in structural steel ONLY with the prior written approval of COR.
- B. The use of chain pipe supports, wire or strap hangers; wood for blocking, stays and bracing, or hangers suspended from piping above shall not be permitted. Rusty products shall be replaced.
- C. Hanger rods shall be used that are straight and vertical. Turnbuckles for vertical adjustments may be omitted where limited space prevents use. A minimum of 15 mm (1/2 inch) clearance between pipe or piping covering and adjacent work shall be provided.
- D. For horizontal and vertical plumbing pipe supports, refer to the International Plumbing Code (IPC) 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 shall 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 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. Structural drawings shall be reviewed for additional requirements. Bases shall be neatly finished and smoothed, shall have chamfered edges at the top, and shall be suitable for painting.

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3. All equipment shall be shimmed, leveled, firmly anchored, and grouted with epoxy grout. Anchor bolts shall be placed in sleeves, anchored to the bases. Fill the annular space between sleeves and bolts with a grout material to permit alignment and realignment.

3.5 LUBRICATION

- A. All equipment and devices requiring lubrication shall be lubricated prior to initial operation. All devices and equipment shall be field checked for proper lubrication.
- B. All devices and equipment shall be equipped with required lubrication fittings. A minimum of one liter (one quart) of oil and 0.45 kg (1 pound) of grease of manufacturer's recommended grade and type for each different application shall be provided. All materials shall be delivered to COR in unopened containers that are properly identified as to application.
- C. A separate grease gun with attachments for applicable fittings shall be provided for each type of grease applied.
- D. All lubrication points shall be accessible without disassembling equipment, except to remove access plates.
- E. All lubrication points shall be extended to one side of the equipment.

3.6 PLUMBING SYSTEMS DEMOLITION

- A. Rigging access, other than indicated on the drawings, shall be provided after approval for structural integrity by the COR. Such access shall be provided without additional cost or time to the Government. Where work is in an operating plant, approved protection from dust and debris shall be provided at all times for the safety of plant personnel and maintenance of plant operation and environment of the plant.
- B. In an operating plant, cleanliness and safety shall be maintained. The plant shall be kept in an operating condition. Government personnel will be carrying on their normal duties of operating, cleaning and maintaining equipment and plant operation. Work shall be confined to the immediate area concerned; maintain cleanliness and wet down demolished materials to eliminate dust. Dust and debris shall not be permitted to accumulate in the area to the detriment of plant operation. All flame cutting shall be performed to maintain the fire safety integrity of this plant. Adequate fire extinguishing facilities

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shall be available at all times. All work shall be performed in accordance with recognized fire protection standards including NFPA 51B. Inspections will be made by personnel of the VA Medical Center, and the 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 equipment pads, pipe, valves, fittings, insulation, and all hangers including the top connection and any fastenings to building structural systems. All openings shall be sealed after removal of equipment, pipes, ducts, and other penetrations in roof, walls, floors, in an approved manner and in accordance with plans and specifications where specifically covered. Structural integrity of the building system shall be maintained. Reference shall also be made to the drawings and specifications of the other disciplines in the project for additional facilities to be demolished or handled.
- D. All valves including gate, globe, ball, butterfly and check, all pressure gages and thermometers with wells shall remain Government property and shall be removed and delivered to COR and stored as directed. The Contractor shall remove all other material and equipment, devices and demolition debris under these plans and specifications. Such material shall be removed from Government property expeditiously and shall not be allowed to accumulate. 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 shall be thoroughly cleaned and painted. Refer to Section 09 91 00, PAINTING.

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B. In addition, the following special conditions apply:

1. Cleaning shall be thorough. Solvents, cleaning materials and methods recommended by the manufacturers shall be used for the specific tasks. All rust shall be removed prior to painting and from surfaces to remain unpainted. Scratches, scuffs, and abrasions shall be repaired prior to applying prime and finish coats.
2. The following Material and Equipment shall NOT be painted:
 - a. Motors, controllers, control switches, and safety switches.
 - b. Control and interlock devices.
 - c. Regulators.
 - d. Pressure reducing valves.
 - e. Control valves and thermostatic elements.
 - f. Lubrication devices and grease fittings.
 - g. Copper, brass, aluminum, stainless steel and bronze surfaces.
 - h. Valve stems and rotating shafts.
 - i. Pressure gages and thermometers.
 - j. Glass.
 - k. Name plates.
3. Control and instrument panels shall be cleaned and damaged surfaces repaired. Touch-up painting shall be made with matching paint type and color obtained from manufacturer or computer matched.
4. Pumps, motors, steel and cast iron bases, and coupling guards shall be cleaned, and shall be touched-up with the same paint type and color as utilized by the pump manufacturer.
5. Temporary Facilities: Apply paint to surfaces that do not have existing finish coats per Section 09 91 00, Painting.
6. The final result shall be a smooth, even-colored, even-textured factory finish on all items. The entire piece of equipment shall be repainted, if necessary, to achieve this. Lead based paints shall not be used.

3.8 IDENTIFICATION SIGNS

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

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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, and performance data shall 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 shall be performed as described in the equipment specifications. Vibration within specified tolerance shall be verified prior to extended operation. Temporary use of equipment is specified in Section 01 00 00, GENERAL REQUIREMENTS, Article, TEMPORARY USE OF MECHANICAL AND ELECTRICAL EQUIPMENT.

3.10 OPERATING AND PERFORMANCE TESTS

- A. Prior to the final inspection, all required tests shall be performed as specified in Section 01 00 00, GENERAL REQUIREMENTS, Article, TESTS and submit the test reports and records to the COR.
- B. Should evidence of malfunction in any tested system, or piece of equipment or component part thereof, occur during or as a result of tests, make proper corrections, repairs or replacements, and repeat tests at no additional cost to the Government.
- C. When completion of certain work or systems 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 during the first actual seasonal use of the respective systems following completion of work. Rescheduling of these tests shall be requested in writing to COR for approval.
- D. Perform tests as required for commissioning provisions in accordance with Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS and Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

3.11 OPERATION AND MAINTENANCE MANUALS

- A. All new and temporary equipment and all elements of each assembly shall be included.

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

3.12 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.

3.13 DEMONSTRATION AND TRAINING

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

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SECTION 22 05 12

GENERAL MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section describes the general motor requirements for plumbing equipment and applies to all sections of Division 22.
- 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 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.
- F. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- G. Section 26 29 11, MOTOR CONTROLLERS: Starters, control and protection of motors.

1.3 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American Bearing Manufacturers Association (ABMA):
ABMA 9-1990 (R2008).....Load Ratings and Fatigue Life for Ball Bearings
- C. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
841-2009.....IEEE Standard for Petroleum and Chemical
Industry-Premium-Efficiency, Severe-Duty,
Totally Enclosed Fan-Cooled (TEFC) Squirrel
Cage Induction Motors--Up to and Including 370
kW (500 HP)
- D. International Code Council (ICC):
IPC-2012.....International Plumbing Code
- E. National Electrical Manufacturers Association (NEMA):
MG 1-2011.....Motors and Generators

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MG 2-2001 (R2007).....Safety Standard for Construction and Guide for
Selection, Installation and Use of Electric
Motors and Generators
250-2008.....Enclosures for Electrical Equipment (1000 Volts
Maximum)

F. National Fire Protection Association (NFPA):
70-2014.....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 22 05 12, GENERAL MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT", with applicable paragraph identification.
- C. Shop Drawings:
 - 1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
 - 2. Motor nameplate information shall be submitted including electrical ratings, dimensions, mounting details, materials, horsepower, power factor, current as a function of speed, current efficiency, speed as a function of load, RPM, enclosure, starting characteristics, torque characteristics, code letter, full load and locked rotor current, service factor, and lubrication method.
 - 3. Motor parameters required for the determination of the Reed Critical Frequency of vertical hollow shaft motors shall be submitted.
- D. Operating and Maintenance Manuals: Companion copies of complete maintenance and operating manuals, including technical data sheets and application data shall be submitted simultaneously with the shop drawings. Complete operating and maintenance manuals including wiring diagrams, technical data sheets and information for ordering replaceable 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.

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E. Certification: Two weeks prior to final inspection, unless otherwise noted, the following certification shall be submitted to the Contracting Officer's Representative (COR).

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

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>.

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 totally enclosed motors, IEEE 841 shall apply.
- C. Voltage ratings shall be as follows:
 1. Single phase:
 - a. Motors connected to 120-volt systems: 115 volts.
 - b. Motors connected to 208-volt systems: 200 volts.
 - c. Motors connected to 240-volt or 480-volt systems: 230/460 volts, dual connection.
 2. Three phase:
 - a. Motors connected to 208-volt systems: 200 volts.
 - b. Motors, less than 74.6 kW (100 HP), connected to 240-volt or 480-volt systems: 230/460 volts, dual connection.
 - c. Motors connected to high voltage systems: Shall conform to NEMA MG 1 Standards for connection to the nominal system voltage shown on the drawings.
- D. Number of phases shall be as follows:
 1. Motors, less than 373 W (1/2 HP): Single phase.
 2. Motors, 373 W (1/2 HP) and larger: 3 phase.
 3. Exceptions:
 - a. Hermetically sealed motors.

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- b. Motors for equipment assemblies, less than 746 W (1 HP), may be single phase provided the manufacturer of the proposed assemblies cannot supply the assemblies with three phase motors.
- E. 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.
- F. 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.
- G. Motor Enclosures:
 - 1. Shall be the NEMA types shown on the drawings for the motors.
 - 2. Where the types of motor enclosures are not shown on the drawings, they shall be the NEMA types per NEMA 250, which are most suitable for the environmental conditions where the motors are being installed.
 - 3. Enclosures shall be primed and finish coated at the factory with manufacturer's prime coat and standard finish.
 - 4. All motors in hazardous locations shall be approved for the application and meet the Class and Group as required by the area classification.
- H. 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 (144 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.
- I. Mechanical Design Requirements:
 - 1. Bearings shall be rated for a minimum fatigue life of 26,280 hours for belt-driven loads and 100,000 hours for direct-drive loads based

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- on L10 (Basic Rating Life) at full load direct coupled, except vertical high thrust motors which require a 40,000 hour rating. A minimum fatigue life of 40,000 hours is required for VFD drives.
2. Vertical motors shall be capable of withstanding a momentary up thrust of at least 30 percent of normal down thrust.
 3. Grease lubricated bearings shall be designed for electric motor use. Grease shall be capable of the temperatures associated with electric motors and shall be compatible with Polyurea based greases.
 4. Grease fittings, if provided, shall be Alemite type or equivalent.
 5. Oil lubricated bearings, when specified, shall have an externally visible sight glass to view oil level.
 6. Vibration shall not exceed 3.8 mm (0.15 inch) per second, unfiltered peak.
 7. Noise level shall meet the requirements of the application.
 8. Motors on 180 frames and larger shall have provisions for lifting eyes or lugs capable of a safety factor of 5.
 9. All external fasteners shall be corrosion resistant.
 10. Condensation heaters, when specified, shall keep motor windings at least 5 degrees C (9 degrees F) above ambient temperature.
 11. Winding thermostats, when specified shall be normally closed, connected in series.
 12. Grounding provisions shall be in the main terminal box.
- J. Additional requirements for specific motors, as indicated in other sections, shall also apply.
- K. 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, and as specified in this specification. Motors of 746 W (1 HP) or more with open, drip-proof or totally enclosed fan-cooled enclosures shall be 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 Efficiencies	Minimum Efficiencies
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Open Drip-Proof				Totally Enclosed Fan-Cooled			
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%

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

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install motors in accordance with manufacturer's recommendations, the NEC, NEMA, as shown on the drawings and/or as required by other sections of these specifications.
- B. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no cost to the Government.

3.2 FIELD TESTS

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

3.3 COMMISSIONING

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

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SECTION 22 05 19

METERS AND GAGES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section describes the requirements for water meters and gages primarily used for troubleshooting the system and to indicate system performance.
- 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 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

1.3 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American Society of Mechanical Engineers (ASME):
 - B40.100-2013.....Pressure Gauges and Gauge Attachments
 - B40.200-2008.....Thermometers, Direct Reading and Remote Reading
- C. International Code Council (ICC):
 - IPC-2012.....International Plumbing Code
- D. National Fire Protection Association (NFPA):
 - 70-2014.....National Electrical Code (NEC)
- E. NSF International (NSF):
 - 61-2012.....Drinking Water System Components - Health Effects
 - 372-2011.....Drinking Water System Components - Lead Content

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.

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- B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 22 05 19, METERS AND GAGES 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. Pressure Gages.
 - 2. Thermometers.
 - 3. Product certificates for each type of gage.
- D. Operations and Maintenance manual shall include:
 - 1. Troubleshooting and preventive maintenance guidelines.
 - 2. Spare parts information.

1.5 AS-BUILT DOCUMENTATION

- A. Submit manufacturer's literature and data updated to include submittal review comments and any equipment substitutions.
- B. Submit copies of complete operation and maintenance data updated to include submittal review comments, substitutions and construction revisions shall be inserted into a three ring binder per the requirements of Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA AND SAMPLES. All aspects of system operation and maintenance procedures, 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. A list of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.

PART 2 - PRODUCTS

2.1 PRESSURE GAGES FOR WATER AND SEWAGE USAGE

- A. ASME B40.100 all metal case 115 mm (4-1/2 inches) diameter, bottom connected throughout, graduated as required for service, and identity labeled. Range shall be 0 to 1380 kPa (0 to 200 psig) gage.
- B. The pressure element assembly shall be bourdon tube. The mechanical movement shall be lined to pressure element and connected to pointer.

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- C. The dial shall be non-reflective aluminum with permanently etched scale markings graduated in kPa and psig.
- D. The pointer shall be dark colored metal.
- E. The window shall be glass.
- F. The ring shall be brass or stainless steel.
- G. The accuracy shall be grade A, plus or minus 1 percent of middle half of scale range.
- H. The pressure gage for water domestic use shall conform to NSF 61 and NSF 372.

2.2 THERMOMETERS

- A. Thermometers shall be straight stem, metal case, red liquid-filled thermometer, approximately 7 inches high, 40 degrees F to 212 degrees F.
- F. Thermometers shall comply with ASME B40.200.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Direct mounted pressure gages shall be installed in piping tees with pressure gage located on pipe at the most readable position.
- B. Valves and snubbers shall be installed in piping for each pressure gage.
- C. Test plugs shall be installed on the inlet and outlet pipes of all heat exchangers or water heaters serving more than one plumbing fixture.
- D. Pressure gages shall be installed where indicated on the drawings and at the following locations:
 - 1. Inlet and outlet of each backflow preventer.
- E. Thermometers shall be installed on the water heater inlet and outlet piping, thermostatic mixing valve outlet piping, and the hot water circulation pump inlet piping.
- F. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no cost to the Government.

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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 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 22 05 11, COMMON WORK RESULTS FOR PLUMBING.
- F. Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

1.3 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American Society of Mechanical Engineers (ASME):
 - A112.14.1-2003.....Backwater Valves
- C. American Society of Sanitary Engineering (ASSE):
 - 1011-2004.....Performance Requirements for Hose Connection Vacuum Breakers
 - 1013-2011.....Performance Requirements for Reduced Pressure Principle Backflow Preventers and Reduced Pressure Principle Fire Protection Backflow Preventers
- D. American Society for Testing and Materials (ASTM):
 - A126-2004(R2009).....Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
 - A276-2013a.....Standard Specification for Stainless Steel Bars and Shapes

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- A536-1984(R2009).....Standard Specification for Ductile Iron
Castings
- B62-2009.....Standard Specification for Composition Bronze
or Ounce Metal Castings
- B584-2013.....Standard Specification for Copper Alloy Sand
Castings for General Applications
- E. International Code Council (ICC):
IPC-2012.....International Plumbing Code
- F. Manufacturers Standardization Society of the Valve and Fittings
Industry, Inc. (MSS):
SP-25-2008.....Standard Marking Systems for Valves, Fittings,
Flanges and Unions
SP-67-2011.....Butterfly Valves
SP-71-2011.....Gray Iron Swing Check Valves, Flanged and
Threaded Ends
SP-80-2013.....Bronze Gate, Globe, Angle, and Check Valves
SP-110-2010.....Ball Valves Threaded, Socket-Welding, Solder
Joint, Grooved and Flared Ends
- G. National Environmental Balancing Bureau (NEBB):
7th Edition 2005 Procedural Standards for Testing, Adjusting,
Balancing of Environmental Systems
- H. NSF International (NSF):
61-2012.....Drinking Water System Components - Health
Effects
372-2011.....Drinking Water System Components - Lead Content
- I. University of Southern California Foundation for Cross Connection
Control and Hydraulic Research (USC FCCCHR):
9th 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
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- C. Manufacturer's Literature and Data Including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.
 - 1. Ball Valves.
 - 2. Butterfly Valves.
 - 3. Check Valves.
 - 4. Backflow Preventers.
 - 5. Chainwheels.
 - 6. Thermostatic Mixing Valves.
- D. Complete operating and maintenance manuals including wiring diagrams, technical data sheets and information for ordering replaceable 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.
 - 4. Piping diagrams of thermostatic mixing valves to be installed.
- E. Completed System Readiness Checklist provided by the Commissioning Agent and completed by the Contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

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.

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- 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.

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

2.2 SHUT-OFF VALVES

- A. Cold, Hot 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, Alloy C844. The ends shall be non-lead solder.
 2. Less than 100 mm DN100 (4 inches): Butterfly shall have an iron body with EPDM seal and aluminum bronze disc. The butterfly valve shall

meet MSS SP-67, type I standard. The butterfly valve shall have a SWP rating of 1380 kPa (200 psig). The valve design shall be lug type suitable for bidirectional dead-end service at rated pressure. The body material shall meet ASTM A536, ductile iron.

3. 100 mm DN100 (4 inches) and larger:

- a. 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.

- 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 larger:

- 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.

2.4 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

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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. 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, cooling tower, chilled water system, generators, and similar equipment consuming water.

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 backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction. Locate backflow preventers in same room as connected equipment or system.
 - 1. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe to floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are not acceptable for this application.
- G. Install pressure gages on outlet of backflow preventers.
- H. Do not install bypass piping around backflow preventers.
- I. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no cost to the Government.

3.4 COMMISSIONING

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

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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 CxA.
- B. The Plumbing systems commissioning will include the systems listed in Section 01 19 00 General Commissioning Requirements:

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1.6 SUBMITTALS

- A. The commissioning process requires review of selected Submittals. The CxA will provide a list of submittals that will be reviewed by the CxA. 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. Contractor shall coordinate with the CxA 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 CxA 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 CxA for review. The CxA may spot check a sample of completed checklists. If the CxA determines that the information provided on the checklist is not accurate, the CxA will return the marked-up checklist to the Contractor for correction and resubmission. If the CxA determines that a significant number of completed checklists for similar equipment are not accurate, the CxA will select a broader sample of checklists for review. If the CxA 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

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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 CxA 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 CxA will prepare detailed Systems Functional Performance Test procedures for review and approval by the Contracting Officer's Representative (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 CxA 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 CxA. 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 19 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 22 Sections for additional Contractor training requirements.

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**SECTION 22 11 00
FACILITY WATER DISTRIBUTION**

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Domestic water systems, including piping, equipment and all necessary accessories as designated in this section.
- B. A complete listing of all acronyms and abbreviations are included in Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- C. Section 01 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 22 05 11, COMMON WORK RESULTS FOR PLUMBING.
- I. Section 22 07 11, PLUMBING INSULATION.
- J. SECTION 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

1.3 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American Society of Mechanical Engineers (ASME):
 - A13.1-2007 (R2013).....Scheme for Identification of Piping Systems
 - B16.9-2012.....Factory-Made Wrought Buttwelding Fittings
 - B16.18-2012.....Cast Copper Alloy Solder Joint Pressure Fittings
 - B16.22-2013.....Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings
 - B16.24-2011.....Cast Copper Alloy Pipe Flanges and Flanged Fittings: Classes 150, 300, 600, 900, 1500, and 2500
 - B16.51-2013.....Copper and Copper Alloy Press-Connect Fittings
- ASME Boiler and Pressure Vessel Code -

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BPVC Section IX-2015....Welding, Brazing, and Fusing Qualifications

C. American Society of Sanitary Engineers (ASSE):

1010-2004.....Performance Requirements for Water Hammer
Arresters

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

A183-2014.....Standard Specification for Carbon Steel Track
Bolts and Nuts

A312/A312M-2015.....Standard Specification for Seamless, Welded,
and Heavily Cold Worked Austenitic Stainless
Steel Pipes

B32-2008 (R2014).....Standard Specification for Solder Metal

B88-2014.....Standard Specification for Seamless Copper
Water Tube

B687-1999 (R2011).....Standard Specification for Brass, Copper, and
Chromium-Plated Pipe Nipples

D1785-2012.....Standard Specification for Poly (Vinyl
Chloride) (PVC) Plastic Pipe, Schedules 40, 80,
and 120

D2000-2012.....Standard Classification System for Rubber
Products in Automotive Applications

D2564-2012.....Standard Specification for Solvent Cements for
Poly (Vinyl Chloride) (PVC) Plastic Piping
Systems

D2855-1996 (R2010).....Standard Practice for Making Solvent-Cemented
Joints with Poly (Vinyl Chloride) (PVC) Pipe
and Fittings

E1120-2008.....Standard Specification for Liquid Chlorine

E1229-2008.....Standard Specification for Calcium Hypochlorite

E. American Water Works Association (AWWA):

C651-2014.....Disinfecting Water Mains

F. American Welding Society (AWS):

A5.8M/A5.8-2011-AMD1....Specification for Filler Metals for Brazing and
Braze Welding

G. International Code Council (ICC):

IPC-2012.....International Plumbing Code

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H. Manufacturers Specification Society (MSS):

SP-58-2009.....Pipe Hangers and Supports - Materials, Design,
Manufacture, Selection, Application, and
Installation

SP-72-2010a.....Ball Valves with Flanged or Butt-Welding Ends
for General Service

SP-110-2010.....Ball Valves Threaded, Socket-Welding, Solder
Joint, Grooved and Flared Ends

I. NSF International (NSF):

14-2015.....Plastics Piping System Components and Related
Materials

61-2014a.....Drinking Water System Components - Health
Effects

372-2011.....Drinking Water System Components - Lead Content

J. Plumbing and Drainage Institute (PDI):

PDI-WH 201-2010.....Water Hammer Arrestors

K. Department of Veterans Affairs:

H-18-8-2013.....Seismic Design Handbook

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. Submit proposed domestic potable water flushing and sterilization procedures and system testing results.

E. Completed System Readiness Checklist provided by the CxA and completed by the Contractor, signed by a qualified technician and dated on the

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date of completion, in accordance with the requirements of Section 22
08 00, COMMISSIONING OF PLUMBING SYSTEMS.

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 pipe, couplings, fittings, and specialties shall bear the identification of the manufacturer and any markings required by the applicable referenced standards.
- C. Comply with standards of authorities having jurisdiction for potable-water-service piping, including materials, installation, testing, and disinfection.
- 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 SPARE PARTS

- A. For mechanical press-connect fittings, provide tools required for each pipe size used at the facility.

1.7 AS-BUILT DOCUMENTATION

- A. Submit manufacturer's literature and data updated to include submittal review comments and any equipment substitutions.
- B. Submit operation and maintenance data updated to include submittal review comments, substitutions and construction revisions shall be inserted into a three ring binder. 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 2012

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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 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.

2.2 ABOVE GROUND (INTERIOR) WATER PIPING

- A. Pipe: Copper tube, ASTM B88, Type K, drawn. For pipe 150 mm (6 inches) and larger, stainless steel, ASTM A312, schedule 10 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. Mechanical press-connect fittings for copper pipe and tube shall conform to the material and sizing requirements of ASME B16.51, NSF 61 approved, 50 mm (2 inch) size and smaller mechanical press-connect fittings, double pressed type, with EPDM (ethylene propylene diene monomer) non-toxic synthetic rubber sealing elements and un-pressed fitting identification feature.
 3. Flanged fittings, bronze, class 150, solder-joint ends conforming to ASME B16.24.

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C. Fittings for Stainless Steel:

1. Stainless steel butt-welded fittings, Type 316, Schedule 10, conforming to ASME B16.9.
2. Flanged fittings, stainless steel, class 150, welded ends conforming to ASME B16.5.

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.

G. Reverse Osmosis (RO) Water Piping:

1. RO Product Tubing ASTM D1785, Schedule 80 PVC, ASTM D2855 socket welded and flanged.
2. RO Product Tubing within 10 feet of heat exchangers, Stainless steel, ASTM A312, Schedule 10 with stainless steel butt welded or sanitary clamp fittings.

2.3 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.

2.4 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 than 75 mm (3 inches), brass or bronze; 75 mm (3 inches) and greater, cast iron or semi-steel.

2.5 DIELECTRIC FITTINGS

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

2.6 STERILIZATION CHEMICALS

A. Hypochlorite: ASTM E1120.

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B. Liquid Chlorine: ASTM E1229.

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, 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.

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- 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. 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.

8. Mechanical press-connect fitting connections shall be made in accordance with the manufacturer's installation instructions. The tubing shall be fully inserted into the fitting and the tubing marked at the shoulder of the fitting. The fitting alignment shall be checked against the mark on the tubing to assure the tubing is fully engaged (inserted) in the fitting. Ensure the tube is completely inserted to the fitting stop (appropriate depth) and squared with the fitting prior to applying the pressing jaws onto the fitting. The joints shall be pressed using the tool(s) approved by the manufacturer. Minimum distance between fittings shall be in accordance with the manufacturer's requirements. When the pressing cycle is complete, visually inspect the joint to ensure the tube has remained fully inserted, as evidenced by the visible insertion mark.

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 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 of 1035 kPa (150 psig) gage for two hours. No decrease in pressure is allowed. Provide a pressure gage

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with a shutoff and bleeder valve at the highest point of the piping being tested. Pressure gauge shall have 1 psig increments.

- C. RO Water Systems: Fill system with water and maintain hydrostatic pressure of 1380 kPa (200 psig) gage during inspection and prove tight.
- D. All Other Piping Tests: Test new installed piping under 1-1/2 times actual operating conditions and prove tight.
- E. 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.

3.4 COMMISSIONING

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

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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 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: Sealant products.
- G. Section 09 91 00, PAINTING: Preparation and finish painting and identification of piping systems.
- H. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING: Pipe Hangers and Supports, Materials Identification.
- I. Section 22 07 11, PLUMBING INSULATION.
- J. Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS
- K. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS
- L. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

1.3 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American Society of Mechanical Engineers (ASME):
 - A13.1-2007.....Scheme for the Identification of Piping Systems
 - A112.36.2M-1991(R 2012).Cleanouts
 - A112.6.3-2001 (R2007)...Standard for Floor and Trench Drains
 - B1.20.1-2013.....Pipe Threads, General Purpose (Inch)
 - B16.23-2011.....Cast Copper Alloy Solder Joint Drainage Fittings: DWV

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B16.29-2012.....Wrought Copper and Wrought Copper Alloy Solder-
Joint Drainage Fittings: DWV

B18.2.1-2012.....Square, Hex, Heavy Hex, and Askew Head Bolts
and Hex, Heavy Hex, Hex Flange, Lobed Head, and
Lag Screws (Inch Series)

C. American Society of Sanitary Engineers (ASSE):

1001-2008.....Performance Requirements for Atmospheric Type
Vacuum Breakers

1018-2001.....Performance Requirements for Trap Seal Primer
Valves - Potable Water Supplied

1079-2012.....Performance Requirements for Dielectric Pipe
Unions

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

A74-2013a.....Standard Specification for Cast Iron Soil Pipe
and Fittings

A888-2013a.....Standard Specification for Hubless Cast Iron
Soil Pipe and Fittings for Sanitary and Storm
Drain, Waste, and Vent Piping Applications

B32-2008.....Standard Specification for Solder Metal

B306-2013.....Standard Specification for Copper Drainage Tube
(DWV)

B813-2010.....Standard Specification for Liquid and Paste
Fluxes for Soldering of Copper and Copper Alloy
Tube

B828-2002 (R 2010).....Standard Practice for Making Capillary Joints
by Soldering of Copper and Copper Alloy Tube
and Fittings

C564-2012.....Standard Specification for Rubber Gaskets for
Cast Iron Soil Pipe and Fittings

F1545-1997 (R 2009).....Standard Specification for Plastic-Lined
Ferrous Metal Pipe, Fittings, and Flanges

E. Cast Iron Soil Pipe Institute (CISPI):

2006.....Cast Iron Soil Pipe and Fittings Handbook

301-2012.....Standard Specification for Hubless Cast Iron
Soil Pipe and Fittings for Sanitary and Storm
Drain, Waste, and Vent Piping Applications

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

F. Copper Development Association, Inc. (CDA):

A4015.....Copper Tube Handbook

G. International Code Council (ICC):

IPC-2012.....International Plumbing Code

H. Manufacturers Standardization Society (MSS):

SP-123-2013.....Non-Ferrous Threaded and Solder-Joint Unions
for Use With Copper Water Tube

I. National Fire Protection Association (NFPA):

70-2014.....National Electrical Code (NEC)

J. Plumbing and Drainage Institute (PDI):

WH-201 (R 2010).....Water Hammer Arrestors Standard

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

508-99 (R2013).....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.

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

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. 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 on Auto-Cad version 2012 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.
- B. 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 a certification that all results of tests were within limits specified.

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.

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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.

2.2 SPECIALTY PIPE FITTINGS

- A. Transition pipe couplings shall join piping with small differences in outside diameters or different materials. End connections shall be of the same size and compatible with the pipes being joined. The transition coupling shall be elastomeric, sleeve type reducing or transition pattern and include shear and corrosion resistant metal, tension band and tightening mechanism on each end. The transition coupling sleeve coupling shall be of the following material:
 1. For cast iron soil pipes, the sleeve material shall be rubber conforming to ASTM C564.
 2. For dissimilar pipes, the sleeve material shall be PVC conforming to ASTM D5926, or other material compatible with the pipe materials being joined.
- B. The dielectric fittings shall conform to ASSE 1079 with a pressure rating of 861 kPa (125 psig) at a minimum temperature of 82 degrees C (180 degrees F). The end connection shall be solder joint copper alloy and threaded ferrous.
- C. Dielectric flange insulating kits shall be of non-conducting materials for field assembly of companion flanges with a pressure rating of 1035 kPa (150 psig). The gasket shall be neoprene or phenolic. The bolt sleeves shall be phenolic or polyethylene. The washers shall be phenolic with steel backing washers.
- D. The di-electric nipples shall be electroplated steel nipple complying with ASTM F1545 with a pressure rating of 2070 kPa (300 psig) at 107 degrees C (225 degrees F). The end connection shall be male threaded. The lining shall be inert and noncorrosive propylene.

2.3 CLEANOUTS

- A. Cleanouts shall be the same size as the pipe, up to 100 mm (4 inches); and not less than 100 mm (4 inches) for larger pipe. Cleanouts shall be easily accessible and shall be gastight and watertight. Minimum

clearance of 600 mm (24 inches) shall be provided for clearing a clogged sanitary line.

- B. Floor cleanouts shall be gray iron housing with clamping device and round, secured, scoriated, gray iron cover conforming to ASME A112.36.2M. A gray iron ferrule with hubless, socket, inside calk or spigot connection and counter sunk, taper-thread, brass or bronze closure plug shall be included. The frame and cover material and finish shall be nickel-bronze copper alloy with a square shape. The cleanout shall be vertically adjustable for a minimum of 50 mm (2 inches). When a waterproof membrane is used in the floor system, clamping collars shall be provided on the cleanouts. Cleanouts shall consist of wye fittings and eighth bends with brass or bronze screw plugs. 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 drawings 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 cleanout plug located approximately 600 mm (24 inches) above the floor. If there are no fixtures installed on the lowest floor, cleanout shall be installed at the base of the stack. The cleanouts shall be extended to the wall access cover. Cleanout shall consist of sanitary tees. Nickel-bronze square frame and stainless steel cover with minimum opening of 150 by 150 mm (6 by 6 inches) shall be furnished at each wall cleanout. Where the piping is concealed, a fixture trap or a fixture with integral trap, readily removable without disturbing concealed pipe, shall be accepted as a cleanout equivalent providing the opening to be used as a cleanout opening is the size required.
- D. In horizontal runs above grade, cleanouts shall consist of cast brass tapered screw plug in fitting or caulked/hubless cast iron ferrule. Plain end (hubless) piping in interstitial space or above ceiling may use plain end (hubless) blind plug and clamp.

2.4 FLOOR DRAINS

- A. 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 will 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 1.1 to 1.8 Kg (2.5 to 4 lbs.) flashing membrane, 600 mm (24 inches) square or another approved waterproof membrane shall be provided.

- B. Type E (FD-E) floor drain shall comply with ASME A112.6.3. The type E floor drain shall have a heavy, cast iron body, double drainage pattern, heavy non-tilting ductile iron grate not less than 300 mm (12 inches) square, removable sediment bucket. Clearance between body and bucket shall be ample for free flow of waste water.

2.5 TRAPS

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

2.6 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.

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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.

PART 3 - EXECUTION

3.1 PIPE INSTALLATION

- A. The pipe installation shall comply with the requirements of the International Plumbing Code (IPC) and these specifications.
- B. Branch piping shall be installed for waste from the respective piping systems and connect to all fixtures, valves, cocks, outlets, casework, cabinets and equipment, including those furnished by the Government or specified in other sections.
- C. Pipe shall be round and straight. Cutting shall be done with proper tools. Pipe shall be reamed to full size after cutting.
- D. All pipe runs shall be laid out to avoid interference with other work.
- E. The piping shall be installed above accessible ceilings where possible.
- F. The piping shall be installed to permit valve servicing or operation.
- G. The piping shall be installed free of sags and bends.
- H. Seismic restraint shall be installed where required by code.
- I. Changes in direction for soil and waste drainage and vent piping shall be made using appropriate branches, bends and long sweep bends.
Sanitary tees and short sweep quarter bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Long turn double wye branch and eighth bend fittings shall be used if two fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Proper size of standard increaser and reducers shall be used if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.
- J. 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. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no cost to the Government.

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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.

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 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.
- 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 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.

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- H. Thrust bracing of horizontal no-hub cast iron pipe, fitting and couplings over 4" in size meet the intent of CISPI Designation 310-04, CISPI Designation 301-09 and the CISPI Cast Iron Soil Pipe Handbook, regarding auxiliary support for no-hub cast iron pipe and fitting joints subjected to excessive thrust forces. Use manufactured assemblies with appropriate thrust pressure ratings, rather than field assembled miscellaneous materials.
- I. Cast escutcheon with set screw shall be provided at each wall, floor and ceiling penetration in exposed finished locations and within cabinets and millwork.
- J. Penetrations:
 - 1. Fire Stopping: Where pipes pass through fire partitions, fire walls, smoke partitions, or floors, a fire stop shall be installed that provides an effective barrier against the spread of fire, smoke and gases as specified in Section 07 84 00, FIRESTOPPING. Clearances between raceways and openings shall be completely filled and sealed with the fire stopping materials.
 - 2. Water proofing: At floor penetrations, clearances shall be completely sealed around the pipe and make watertight with sealant as specified in Section 07 92 00, JOINT SEALANTS.
- K. Exhaust vents shall be extended separately through roof. Sanitary vents shall not connect to exhaust vents.

3.5 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 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

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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 air test.
3. After installing all fixtures and equipment, open water supply so that all p-traps can be observed. For 15 minutes of operation, all p-traps shall be inspected for leaks and any leaks found shall be corrected.
4. Final Tests: Either one of the following tests may be used.
 - a. Smoke Test: After fixtures are permanently connected and traps are filled with water, fill entire drainage and vent systems with smoke under pressure of .25 kPa (1 inch of water) with a smoke machine. Chemical smoke is prohibited.
 - b. Peppermint Test: Introduce 60 ml (2 ounces) of peppermint into each line or stack.

3.6 COMMISSIONING

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

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SECTION 22 15 00
GENERAL SERVICE COMPRESSED-AIR SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section describes the requirements for compressed air systems for non-medical air piping materials, including compressors, electric motors and starters, receiver, all necessary piping, fittings, valves, gages, switches and all necessary accessories, connections and equipment.
- 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 22 05 11, COMMON WORK RESULTS FOR PLUMBING.
- F. Section 22 05 12, GENERAL MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT.
- G. Section 22 05 19, METERS AND GAGES FOR PLUMBING PIPING: Exposed Piping and Gages.
- H. SECTION 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.
- I. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
- J. Section 26 29 11, MOTOR CONTROLLERS.

1.3 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American Society of Mechanical Engineers (ASME):
 - A13.1-2007.....Scheme for the Identification of Piping Systems
 - B16.21-2011.....Nonmetallic Flat Gaskets for Pipe Flanges
 - B16.22-2013.....Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings

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- B16.24-2011.....Cast Copper Alloy Pipe Flanges and Flanged
Fittings: Classes 150, 300, 600, 900, 1500, and
2500
- B18.2.1-2012.....Square, Hex, Heavy Hex, and Askew Head Bolts
and Hex, Heavy Hex, Hex Flange, Lobed Head, and
Lag Screws (Inch Series)
- ASME Boiler and Pressure Vessel Code -
BPVC Section VIII-1-2013 Rules for Construction of Pressure
Vessels, Division 1
- C. American Society for Testing and Materials (ASTM):
- B32-2008.....Standard Specification for Solder Metal
- B62-2009.....Standard Specification for Composition Bronze
or Ounce Metal Castings
- B88-2009.....Standard Specification for Seamless Copper
Water Tube
- B584-2013.....Standard Specification for Copper Alloy Sand
Castings for General Applications
- B813-2010.....Standard Specification for Liquid and Paste
Fluxes for Soldering of Copper and Copper Alloy
Tube
- B819-2000 (R2011).....Standard Specification for Seamless Copper Tube
for Medical Gas Systems
- D. American Welding Society (AWS):
- A5.8/A5.8M AMD1-2011....Specification for Filler Metals for Brazing and
Braze Welding
- E. International Code Council (ICC):
- IPC-2012.....International Plumbing Code
- F. Manufacturer Standardization of the Valve and Fittings Industry, Inc
(MSS):
- SP-80-2013.....Bronze Gate, Globe, Angle, and Check Valves
- SP-110-2010.....Ball Valves Threaded, Socket-Welding, Solder
Joint, Grooved and Flared Ends
- SP-123-2013.....Non-Ferrous Threaded and Solder-Joint Unions
for Use with Copper Water Tube

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G. National Electrical Manufacturers Association (NEMA):

250-2008.....Enclosures for Electrical Equipment (1000 Volts
Maximum)

H. National Fire Protection Association (NFPA):

70-2014.....National Electrical Code (NEC)

99-2012.....Health Care Facilities Code

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

508-1999 (R2013).....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 15 00, GENERAL SERVICE COMPRESSED-AIR SYSTEMS", with applicable paragraph identification.

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

1. Aboveground Piping

2. Supporting elements

3. Valves

4. Pressure Gages

5. Air Pressure Reducing and Regulating Valves

6. Automatic drain valves

7. Filter capacity and operating characteristics

8. Vibration Isolation

9. Air Compressor System:

a. Characteristic performance curves

b. Efficiency

c. Compressor; manufacturer and model

d. Compressor operating speed

e. Capacity; (free air delivered at indicated pressure)

f. Type of bearing in compressor

g. Type of lubrication

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- h. Capacity of receiver
- i. Unloader; manufacturer, type, and model
- j. Type and adjustment of drive
- k. Electrical motor; manufacturer, frame and model
- l. Speed of motor
- m. Current characteristics and HP of motor
- n. Air muffler filter; manufacture, type, and model
- o. After cooler; manufacturer, type, and model
- D. Pneumatic compressed air system and hydrostatic drainage piping test reports shall be submitted.
- E. Brazing and welding certificates shall be submitted.
- F. Complete operating and maintenance manuals including wiring diagrams, technical data sheets and information for ordering replaceable 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.
- G. Completed System Readiness Checklist provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

1.5 QUALITY ASSURANCE

- A. The Contractor shall obtain the services of a qualified engineer or technician from the compressor manufacturer to review final installation, and supervise start-up, and testing of the compressor. After satisfactory installation of the equipment, the engineer or technician shall provide a signed certification that the equipment is installed in accordance with the manufacturer's recommendations.
- 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>.

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1.6 AS-BUILT DOCUMENTATION

- A. Operation and maintenance data updated to include submittal review comments, substitutions and construction revisions 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.
- B. 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 on Auto-Cad version 2012 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.

PART 2 - PRODUCTS

2.1 PIPES, TUBES AND FITTINGS

- A. Pipe for general service compressed air system shall be drawn temper, Type "K" seamless copper tube, conforming to ASTM B88, ASTM B819 with wrought copper solder joint fittings conforming to ASME B16.22.
- B. Copper unions shall conform to ASME B16.22 or MSS SP-123.
- C. Cast copper alloy flanges shall be Class 300 conforming to ASME B16.24.
1. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos free, 3.2 mm (1/8 inch) maximum thickness, full-face type.
 2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel.
- D. Solder filler metal shall consist of lead free alloys conforming to ASTM B32 with water flushable flux conforming to ASTM B813.

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E. Silver Brazing Filler metals shall be BCuP series, copper phosphorus alloys for general duty brazing conforming to AWS A5.8/A5.8M.

F. Pipe identification shall comply with ASME A13.1.

2.2 VALVES

A. Ball:

1. Ball valves 75 mm or DN75 (3 inches) and smaller shall be full port, two or three piece ball valve conforming to MSS SP-110. The ball valve shall have a SWP rating of 1035 kPa (150 psig) and a CWP rating of 4138 kPa (600 psig). The body material shall be Bronze ASTM B584, Alloy C844. The ends shall be soldered.

B. Check:

1. Check valves smaller than 100 mm or DN100 (4 inches) shall be Class 125, bronze swing check valves with non metallic Buna-N disc. The check valve shall meet MSS SP-80 Type 4 standard. The check valve shall have a CWP rating of 1380 kPa (200 psig). The check valve shall have a Y pattern horizontal body design with bronze body material conforming to ASTM B62, solder joints, and PTFE or TFE disc.

2.3 DIELECTRIC FITTINGS

- A. Fittings joining copper alloy and ferrous materials shall be isolated.
- B. Dielectric unions shall be factory fabricated union assemblies, rated at 1725 kPa (250 psig) minimum working pressure at 82 degrees C (180 degrees F) suitable for compressed air service.
- C. Dielectric flanges shall be factory fabricated companion flange assemblies, rated at 2070 kPa (300 psig) minimum working pressure at 82 degrees C (180 degrees F) suitable for compressed air service.

2.4 FLEXIBLE PIPE CONNECTORS

- A. Stainless steel hose flexible connectors shall be corrugated, stainless steel tubing with stainless steel wire braid covering and ends welded to inner tubing. The stainless steel hose connectors shall be rated at 1380 kPa (200 psig) minimum. The end connections for 50 mm or DN50 (NPS 2 inches) and smaller shall be threaded steel pipe nipple. The end connections for 65 mm or DN65 (NPS 2-1/2 inches) and larger shall be flanged steel nipple.

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- B. Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing. The corrugated- bronze tubing shall be rated at 1380 kPa (200 psig) minimum.

2.5 SPECIALTIES

- A. Pressure Gages: Pressure gages permanently installed in the system or used for testing purposes shall be listed for compressed air service and shall include a snubber or pulsation dampener and an isolation valve for maintenance access.
1. For line pressure use adjacent to source equipment: ASME B40.1, pressure gage, single, size 115 mm (4-1/2 inches), for compressed air, accurate to within two percent, with metal case. Range shall be two times operating pressure. Dial graduations and figures shall be black on a white background, or white on a black background. Gage shall be labeled for appropriate service, and marked "USE NO OIL".
 2. For all services downstream of main shutoff valve: Manufactured for compressed air use and marked "USE NO OIL", 40 mm (1-1/2 inch) diameter gage with dial range 1-690 kPa (1-100 psig) for air service.
- B. Air Pressure Regulating Valves:
1. Air pressure regulating valves under 75 mm or DN75 (NPS 3 inches) shall be pilot or diaphragm operated, bronze body and trim, direct acting, spring loaded manual pressure setting adjustment and rated for 1380 kPa (200 psig) inlet pressure. Delivered pressure shall not vary more than one kPa for each 10 kPa (1.5 psig) variation in inlet pressure.
- C. Safety valves shall be constructed according to the ASME BPVC Section VIII and be National Board Certified, labeled, and factory sealed. The safety valve shall be constructed of bronze body with poppet type safety valve for compressed air service.
- D. The automatic drain valves shall have stainless steel body and internal parts rated for 1380 kPa (200 psig) minimum working pressure. The automatic drain valve shall be capable of automatic discharge of collected condensate.
- E. The coalescing filter shall be capable of removing water and oil aerosols, efficiency of 99.9 percent retention of particles 0.3

micrometer and smaller, with color change dye to indicate when carbon is saturated and warning light to indicate when selected maximum pressure drop has been exceeded. The coalescing filter shall including mounting brackets for wall mount application.

2.6 AIR COMPRESSOR FOR PNEUMATIC SYSTEMS

- A. The packaged air compressor shall be a factory assembled, wired, piped, and tested that deliver air of quality equal to intake air. The packaged air compressor shall be air cooled, duplex continuous duty. The packaged air compressor shall be capable of operating against a pressure of 690 kPa (100 psig).
- B. The automatic control panel shall house local control and protection functions. The control panel shall comply with NEMA 250 Type 12 and UL 508. The motor controllers shall be full voltage, combination magnetic type with under-voltage release feature and motor circuit protector type disconnecting means and short circuit protective device. The control voltage shall be 120 volts or less. The motor overload protection shall consist of overload relays in each phase. Starting devices shall consist of Hand-off-Auto selector switch in cover of control panel plus pilot device for automatic control. Automatic control switches shall alternate lead-lag compressor for duplex arrangement. Compressed air system shall include discharge air pressure gage, air filter maintenance indicator, hour meter, compressor discharge air and coolant temperature gages, and control transformer. For connection to alarm system, an alarm signaling device shall annunciate when backup air compressor is operating, low pressure air, and trip point.
- C. The receivers shall be a steel tank constructed according to ASME BPVC Section VIII. The receiver pressure rating shall be 1035 kPa (150 psig) and bearing appropriate code symbols and markings. The interior finish shall be corrosion resistant. The tank shall include a safety valve, pressure gage, drain, and pressure regulating valves.
- D. The packaged air compressor units shall be secured to a mounting frame strong enough to resist movement due to a seismic event.
- E. The compressor shall be rotary screw, with a maximum speed of 1800 RPM. The Lubrication system may be automatic flood system or forced feed. A

belt guard shall totally enclose all pulleys and shafts. The air compressor shall be capable of operating against a pressure of 690 kPa (100 psig).

- F. Motor and Starter: Refer to Section 22 05 12, GENERAL MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT. Where conflicts occur between this paragraph and Section 22 05 12, GENERAL MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT this paragraph shall take precedence. The motor shall be designed to operate in 49 degrees C (120 degrees F) ambient temperature, ball bearing, voltage and phase as indicated in schedule and conforming to NEMA standards. The maximum motor speed shall be 1800 RPM. The motor shall be of sufficient size to operate compressor without overloading. Each motor with automatic, fully enclosed, magnetic starter as specified in Section 26 29 11, MOTOR CONTROLLERS, controlled by a Hand-off-Auto (HOA) switch.
- G. After Cooler Air Cooled: The after cooler shall be capable of cooling the air stream within 4 degrees C (7 degrees F) of the ambient air temperature before it enters the receiver. After cooler shall be built in accordance with applicable requirements of ASME BPVC Section VIII and be provided with an automatic condensate drain trap. Each compressor shall be provided with an after cooler.
- H. Dryer/Control: The dryer/control shall include a NEMA 12, U.L. labeled control system, duplexed desiccant drying system, duplexed final line filters, duplexed final line regulators, and dew point monitor. All of the above shall be pre-wired and pre-piped in include valving to allow complete air receiver by-pass, as well as air sampling port.
- I. Dryer: Size each desiccant dryer for the peak calculated demand and capable of producing 10 °F (-12 °C) pressure dew point. Dryer purge flow shall be minimized through an on-demand purge saving control system. Include a mounted prefilter rated for 0.01 micron with automatic drain and element change indicator on the inlet of each dryer.
- J. Intake filter shall be finned, dry type and be replaceable by removing cover. Muffling shall be by a series of silencer tubes.
- K. The in line filter shall have a 10 micron element with 237 mL (1/2 pint) safety green transparent bowl. The filter shall be rated at 1035 kPa (150 psig) at 52 degrees C (125 degrees F).

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- L. The Sound level of the compressor package shall not exceed 62 dB(A) when measured in the free field conditions at one meter.
- M. Example of an acceptable product and manufacturer: Quincy QGS series.

2.7 PRESSURE REGULATORS:

- A. For 690 kPa (100 psi) regulator, provide duplex in parallel, valve for maintenance shut-down without service interruption and provide with isolation valves and valve bypass.
- B. Brass or bronze body and trim, reduced pressure range 170 - 850 kPa (25 - 125 psi) adjustable, spring type, diaphragm operated diaphragm operated, relieving. Delivered pressure shall vary not more than one kPa (0.15psi) for each 10 kPa (1.5psi) variation in inlet pressure.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Piping shall be installed concealed from view and protected from physical contact unless indicated to be exposed. Piping shall be installed exposed in mechanical rooms and service areas.
- B. All pipe shall be installed at right angles or parallel to building walls. Diagonal runs are prohibited unless indicated.
- C. Piping shall be installed above accessible ceilings, allowing for sufficient space for ceiling panel removal and to coordinate with other services occupying that that space.
- D. Piping installed adjacent to equipment shall be located to allow for the required service clearances.
- E. Air and drain piping shall be installed with a 1 percent slope downward in direction of flow.
- F. Nipples, flanges, unions, transitions, and special fittings, and valves shall be installed with pressure ratings same as or higher than system pressure rating.
- G. Cast copper alloy companion flange with gasket and soldered joints shall be used to connect equipment and specialties with flanged connections.
- H. Flanged joints may be used instead of specified joint for any piping or tubing system.

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- I. Only eccentric reducers shall be installed where compressed air piping is reduced in direction of flow, with bottoms of both pipes and reducers fitting flush.
- J. Branch connections shall be installed from the top of the main compressed air line. Drain legs and drain trap shall be installed at the end of each main and branch and at all low points in the system.
- K. Thermometers and pressure gages shall be installed on discharge piping from each air compressor and on each receiver.
- L. Valves shall be installed to permit servicing to all equipment.
- M. Pipes shall be installed free of all sags and bends.
- N. Piping shall be cut square and accurately with a tube cutter (sawing is not permitted) to measurements determined at place of installation and worked into place without springing or forcing the pipe. Tube must bottom in each solder socket so there are no gaps between tube and fitting where solder can enter the inside of line. The tube shall be reamed to remove burrs, being careful not to expand tube and that no chips of copper remain in the line. Care shall be exercised in handling equipment and tools used in cutting or reaming of pipe to prevent oil or grease being introduced into piping.
- O. Particular care shall be exercised, when flux is applied to avoid leaving any excess inside the completed joints. Thoroughly wash the outside of each joint with clean hot water after assembly to remove oxide coating.
- P. Hanger spacing shall be based upon NFPA 99.
- Q. The Filtered Muffler shall be mounted to the air compressor outdoor intake line without the use of foundations or support frames. Silencer tubes shall be located between the filter and the housing.
- R. Rigidly support valves and other equipment to prevent strain on tube or joints.
- S. Compressor assembly shall have an equipment identification nameplate and data in accordance with 22 05 11, COMMON WORK RESULTS FOR PLUMBING.
- T. Suitably brace piping against sway and vibration. Bracing shall consist of brackets, anchor chairs, rods, and structural steel for vibration isolation.

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- U. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no cost to the Government.

3.2 PRELIMINARY STAGE TESTS

- A. Preliminary tests shall be performed by the contractor prior to testing witnessed by the COR. Tests shall be pneumatic and shall use dry, oil-free compressed air, carbon dioxide or nitrogen in metallic systems.
- B. Testing of any system for any purpose shall include preliminary testing by swabbing joints under test with standard soap solution and observing for bubbles at internal pressures not in excess of 5 psi.
- C. When testing reveals system leakage, isolate and repair the leaks, replace defective materials where necessary, and retest the system until there is no loss of pressure. Remake leaking gaskets with new gaskets and new flange bolting, and discard used bolting and gaskets.
- D. Drainage piping shall be hydrostatically tested to a pressure of 5 psi to ensure the piping does not leak. Repair all observed leaks and retest until all leaks have been corrected.

3.3 STARTUP AND TESTING

- A. As recommended by product manufacturer and listed standards and under actual or simulated operating conditions, pneumatic tests shall be conducted to prove piping system integrity and full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with each integrated system. Tests shall be pneumatic and shall use dry, oil-free compressed air, carbon dioxide or nitrogen in metallic systems.
- B. The tests shall include initial piping purge test, initial pneumatic test for positive-pressure gas systems, initial cross-connection test, and initial standing positive-pressure gas piping tests, system capacity, control function, and alarm functions.
- C. Pneumatic tests shall be performed utilizing a test pressure of 50 psi higher than the MAWP, minimum of 150 psi. Test pressure shall be maintained for a minimum period of four hours to ensure the temperature in the piping system stabilizes, then the pressure is refreshed and held for two hours with no loss of pressure. Pneumatic testing performance shall be in accordance with industry safety standards with the pressure gradually increased in increments of 25% of the MAWP until

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the required test pressure is reached. At each interval, the system pressure shall be held long enough for piping strains to stabilize. If leaks are observed, the leaks shall be identified, the system depressurized and repairs made before proceeding.

- D. Other than standard piping flanges, plugs, caps and valves, only use commercially manufactured expandable elastomer plugs for sealing off piping for test purposes. Published safe test pressure rating of any plug used shall be not less than three times the actual test pressure being applied. During pneumatic testing evacuate personnel from areas where plugs are used.
- E. Remove components that could be damaged by test pressure from piping systems to be tested.
- F. Perform valve-operating tests and drainage tests to insure valves do not leak when operating under pressure and are correctly labeled.
- G. Check piping system components, such as valves, for proper operation under system test pressure.
- H. No test media shall be added to a system during a test for a period specified or determined by the Contracting Officer.
- I. Duration of a test will be determined by the Contracting Officer and will be for a minimum of 15 minutes with a maximum of 24 hours. Test may be terminated by direction of the Contracting Officer at any point after it has been determined that the pressure leak test has been satisfied.
- J. Prepare and maintain test records of all piping systems tests. Records shall show Governmental and Contractor test personnel responsibilities, dates, test gage identification numbers, ambient temperatures, pressure ranges, rates of pressure drop, and leakage rates.
- K. System verification and final testing shall be conducted comprising of a system verifier standing pressure test, verifier cross-connection test, verifier piping purge test, verifier final tie-in test, verifier operational pressure test, verifier piping particulate test, verifier piping purity test, labeling, and source equipment verification test.
- L. When any defects are detected, correct defects and repeat test at no additional costs to the Government. When testing reveals system leakage, isolate and repair the leaks, replace defective materials

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where necessary, and retest the system until there is no loss of pressure. Remake leaking gaskets with new gaskets and new flange bolting, and discard used bolting and gaskets.

- M. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the Contracting Officer's Representative and Commissioning Agent. Provide a minimum of 7 days prior to notice.

3.4 COMMISSIONING

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

3.5 DEMONSTRATION AND TRAINING

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

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SECTION 22 33 00

ELECTRIC DOMESTIC WATER HEATERS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section describes the requirements for installing a complete electric domestic water heater system ready for operation including the water heaters, thermometers, and all necessary accessories, connections, and equipment.
- 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 09 91 00, PAINTING: Preparation and finish painting and identification.
- E. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.
- F. Section 22 05 19, METERS AND GAGES FOR PLUMBING PIPING,
- G. Section 22 05 23, GENERAL-DUTY VALVES FOR PLUMBING PIPING
- H. Section 22 07 11, PLUMBING INSULATION.
- I. SECTION 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.
- J. Section 22 11 00, FACILITY WATER DISTRIBUTION: Piping, Fittings, Valves and Gages.
- K. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS
- L. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

1.3 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American National Standard Institute (ANSI):
Z21.22B-2001 (R2008)....Relief Valves for Hot Water Supply Systems

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

90.1 (2013).....Energy Standard for Buildings Except Low-Rise
Residential Buildings

D. American Society of Mechanical Engineers (ASME):

B1.20.1-2013.....Pipe Threads, General Purpose (Inch)

F. National Fire Protection Association (NFPA)

70-2014.....National Electrical Code (NEC)

G. NSF International (NSF):

5-2012.....Water Heaters, Hot Water Supply Boilers, and
Heat Recovery Equipment

61-2012.....Drinking Water System Components - Health
Effects

372-2011.....Drinking Water System Components - Lead Content

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 33 00, ELECTRIC DOMESTIC WATER HEATERS", 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. For each electric domestic hot water heater type and size, the following characteristics shall be submitted:

1. Rated Capacities.
2. Operating characteristics.
3. Electrical characteristics.
4. Furnished specialties and accessories.

E. Shop drawings shall include wiring diagrams for power, signal and control functions.

F. Submit documentation indicating compliance with applicable requirements with ASHRAE 90.1 for Service Water Heating.

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- G. Complete operating and maintenance manuals including wiring diagrams, technical data sheets and information for ordering replaceable 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.
- H. Completed System Readiness Checklist provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

1.5 QUALITY ASSURANCE

- A. For commercial applications, comply with American Society of Heating, Refrigerating and Air - Conditioning Engineers (ASHRAE) for efficiency performance. ASHRAE 90.1, "Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings, for commercial water heaters."
- B. Electrical components, devices and accessories shall be listed and labeled as defined in NFPA 70 by a qualified testing agency, and marked for intended location and application.
- C. Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61 and NSF 372.
- D. The domestic water heater shall be certified and labeled by an independent testing agency.
- 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>.

1.6 AS-BUILT DOCUMENTATION

- A. Submit operation and maintenance data updated to include submittal review comments, substitutions and construction revisions 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,

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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.

- B. 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 on Auto-Cad version 2012 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.

PART 2 - PRODUCTS

2.1 ELECTRIC, TANKLESS, DOMESTIC WATER HEATER

- A. Electric, Tankless, domestic water heaters shall be constructed with copper piping or tubing complying with NSF 61 and NSF 372 for barrier materials for potable water heaters without storage capacity.
- B. The pressure rating shall be 1035 kPa (150 psig).
- C. The heating element shall be resistance heating system type.
- D. Temperature control shall be made with thermostat.
- E. The safety control shall be a high temperature limit cutoff device or system.
- F. The heater shall have an enameled jacket with an aluminum or steel floor stand or wall bracket for off-floor mounting.
- G. Heater capacities and electrical characteristics are scheduled on the drawings.

2.2 SUPPORTS

- A. Wall brackets for wall mounted heaters shall be factory-fabricated steel capable of supporting water heater and water.

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PART 3 - EXECUTION

3.1 INSTALLATION

- A. The water heaters shall be installed level and plumb and securely anchored.
- B. The water heaters shall be installed and connected in accordance with manufacturer's written instructions with manufacturer's recommended clearances.
- C. Thermometers shall be installed on the water heater inlet and outlet piping and shall be positioned such that they can be read by an operator or staff standing on floor or walkway.
- D. The thermostatic control shall be set for a minimum setting of 60 degrees C (140 degrees F) for storage heaters and regulated to a maximum discharge temperature of 54 degrees C (130 degrees F) for distribution to personnel.
- E. Dielectric unions shall be provided if there are dissimilar metals between the water heater connections and the attached piping.
- F. Shutoff valves shall be installed on the domestic water supply piping to the water heater and on the domestic hot water outlet piping.
- G. All manufacturer's required clearances shall be maintained.
- H. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no cost to the Government.

3.2 LEAKAGE TEST

- A. Before piping connections are made, water heaters shall be tested with hydrostatic pressure of 1380 kPa (200 psig) and 1654 kPa (240 psig) for a unit with a MAWP of 1103 kPa (160 psig). Any domestic water heater leaking water shall be replaced with a new unit at no additional cost to the VA.

3.3 PERFORMANCE TEST

- A. All of the remote water outlets shall have a minimum of 43 degrees C (110 degrees F) and a maximum of 49 degrees C (120 degrees F) water flow at all times.

3.4 STARTUP AND TESTING

- A. As recommended by product manufacturer and listed standards and under actual or simulated operating conditions, tests shall be conducted to prove full compliance with design and specified requirements. Tests of

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the various items of equipment shall be performed simultaneously with each integrated system.

- B. The tests shall include system capacity, control function, and alarm functions.
- C. When any defects are detected, correct defects and repeat test at no additional costs to the Government.
- D. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the Contracting Officer's Representative and Commissioning Agent. Provide a minimum of 7 days prior to notice.

3.5 COMMISSIONING

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

3.6 DEMONSTRATION AND TRAINING

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

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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.
- B. Definitions:
 - 1. Exposed: Piping, ductwork, and equipment exposed to view in finished rooms.
 - 2. Option or optional: Contractor's choice of an alternate material or method.
 - 3. COR: Contracting Officer's Representative.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES
- C. Section 05 50 00, METAL FABRICATIONS
- D. Section 07 84 00, FIRESTOPPING
- E. Section 07 92 00, JOINT SEALANTS
- F. Section 09 91 00, PAINTING
- G. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION
- 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 07 11, HVAC, and BOILER PLANT INSULATION.
- K. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
- L. Section 23 82 00, CONVECTION HEATING and COOLING UNITS
- M. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS
- N. Section 26 05 19, LOW VOLTAGE ELECTRICAL POWER CONDUCTORS and CABLES.
- O. Section 26 29 11, MOTOR CONTROLLERS

1.3 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

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construction firms and personnel shall be experienced and qualified specialists in industrial and institutional HVAC

B. Flow Rate Tolerance for HVAC Equipment: Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.

C. Equipment Vibration Tolerance:

1. Refer to Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT. Equipment shall be factory-balanced to this tolerance and re-balanced on site, as necessary.
2. After HVAC air balance work is completed and permanent drive sheaves are in place, perform field mechanical balancing and adjustments required to meet the specified vibration tolerance.

D. Products Criteria:

1. Standard Products: Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products for at least 3 years (or longer as specified elsewhere). The design, model and size of each item shall have been in satisfactory and efficient operation on at least three installations for approximately three years. However, digital electronics devices, software and systems such as controls, instruments, computer work station, shall be the current generation of technology and basic design that has a proven satisfactory service record of at least three years. See other specification sections for any exceptions and/or additional requirements.
2. All items furnished shall be free from defects that would adversely affect the performance, maintainability and appearance of individual components and overall assembly.
3. Conform to codes and standards as required by the specifications. Conform to local codes, if required by local authorities such as the natural gas supplier, if the local codes are more stringent than those specified. Refer any conflicts to the COR.
4. Multiple Units: When two or more units of materials or equipment of the same type or class are required, these units shall be products of one manufacturer.
5. Assembled Units: Manufacturers of equipment assemblies, which use components made by others, assume complete responsibility for the final assembled product.

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6. 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.
7. Asbestos products or equipment or materials containing asbestos shall not be used.

E. Equipment Service Organizations:

1. HVAC: Products and systems shall be supported by service organizations that maintain a complete inventory of repair parts and are located within 50 miles to the site.

F. HVAC Mechanical Systems Welding: Before any welding is performed, contractor shall submit a certificate certifying that welders comply with the following requirements:

1. Qualify welding processes and operators for piping according to ASME "Boiler and Pressure Vessel Code", Section IX, "Welding and Brazing Qualifications".
2. Comply with provisions of ASME B31 series "Code for Pressure Piping".
3. Certify that each welder has passed American Welding Society (AWS) qualification tests for the welding processes involved, and that certification is current.

G. 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 drawings and specifications to the COR for resolution. Provide written hard copies or computer files of manufacturer's installation instructions to the COR at least two weeks prior to commencing installation of any item. Installation of the item will not be allowed to proceed until the recommendations are received. Failure to furnish these recommendations is a cause for rejection of the material.
2. Provide complete layout drawings required by Paragraph, SUBMITTALS. Do not commence construction work on any system until the layout drawings have been approved.

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- H. Upon request by Government, provide lists of previous installations for selected items of equipment. Include contact persons who will serve as references, with telephone numbers and e-mail addresses.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES, and with requirements in the individual specification sections.
- B. Contractor shall make all necessary field measurements and investigations to assure that the equipment and assemblies will meet contract requirements.
- C. If equipment is submitted which differs in arrangement from that shown, provide drawings that show the rearrangement of all associated systems. Approval will be given only if all features of the equipment and associated systems, including accessibility, are equivalent to that required by the contract.
- D. Prior to submitting shop drawings for approval, contractor shall certify in writing that manufacturers of all major items of equipment have each reviewed drawings and specifications, and have jointly coordinated and properly integrated their equipment and controls to provide a complete and efficient installation.
- E. Submittals and shop drawings for interdependent items, containing applicable descriptive information, shall be furnished together and complete in a group. Coordinate and properly integrate materials and equipment in each group to provide a completely compatible and efficient.
- F. Samples: Samples will not be required, except for insulation or where materials offered differ from specification requirements. Samples shall be accompanied by full description of characteristics different from specification. The Government, at the Government's expense, will perform evaluation and testing if necessary. The Contractor may submit samples of additional material at the Contractor's option; however, if additional samples of materials are submitted later, pursuant to Government request, adjustment in contract price and time will be made as provided under Article CHANGES of Section 00 72 00, GENERAL CONDITIONS.
- G. Layout Drawings:

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1. Submit complete consolidated and coordinated layout drawings for all new systems, and for existing systems that are in the same areas.
 2. The 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 layout drawings of all piping and duct systems.
 3. Do not install equipment foundations, equipment or piping until layout 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: 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 load calculations for variable spring and constant support hangers.
 6. Wall, floor, and ceiling plates.
- I. HVAC Maintenance Data and Operating Instructions:
1. Maintenance and operating manuals in accordance with Section 01 00 00, GENERAL REQUIREMENTS, Article, INSTRUCTIONS, for systems and equipment.
 2. Provide a listing of recommended replacement parts for keeping in stock supply, including sources of supply, for equipment. Include in

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the listing belts for equipment: Belt manufacturer, model number,
size and style, and distinguished whether of multiple belt sets.

J. Provide copies of approved HVAC equipment submittals to the Testing,
Adjusting and Balancing Subcontractor.

1.5 APPLICABLE PUBLICATIONS

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

B. Air Conditioning, Heating and Refrigeration Institute (AHRI):

1. 430-2009.....Central Station Air-Handling Units

C. American National Standard Institute (ANSI):

1. B31.1-2007.....Power Piping

D. Rubber Manufacturers Association (ANSI/RMA):

1. IP-20-2007.....Specifications for Drives Using Classical
V-Belts and Sheaves

2. IP-21-2009.....Specifications for Drives Using Double-V
(Hexagonal) Belts

3. IP-22-2007.....Specifications for Drives Using Narrow V-Belts
and Sheaves

E. Air Movement and Control Association (AMCA):

1. 410-96.....Recommended Safety Practices for Air Moving
Devices

F. American Society of Mechanical Engineers (ASME):

1. Boiler and Pressure Vessel Code (BPVC):

2. Section I-2007.....Power Boilers

3. Section IX-2007.....Welding and Brazing Qualifications

4. Code for Pressure Piping:

5. B31.1-2007.....Power Piping

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

1. A36/A36M-08.....Standard Specification for Carbon Structural
Steel

2. A575-96(2007).....Standard Specification for Steel Bars, Carbon,
Merchant Quality, M-Grades

3. E84-10.....Standard Test Method for Surface Burning
Characteristics of Building Materials

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4. E119-09c.....Standard Test Methods for Fire Tests of Building Construction and Materials
- H. Manufacturers Standardization Society (MSS) of the Valve and Fittings Industry, Inc:
 1. SP-58-2009.....Pipe Hangers and Supports-Materials, Design and Manufacture, Selection, Application, and Installation
 2. SP 69-2003.....Pipe Hangers and Supports-Selection and Application
 3. SP 127-2001.....Bracing for Piping Systems, Seismic - Wind - Dynamic, Design, Selection, Application
- I. National Electrical Manufacturers Association (NEMA):
 1. MG-1-2009.....Motors and Generators
- J. National Fire Protection Association (NFPA):
 1. 31-06.....Standard for Installation of Oil-Burning Equipment
 2. 54-09.....National Fuel Gas Code
 3. 70-14.....National Electrical Code
 4. 85-07.....Boiler and Combustion Systems Hazards Code
 5. 90A-15.....Standard for the Installation of Air Conditioning and Ventilating Systems
 6. 92-15Standard for Smoke Control Systems
 7. 101-15.....Life Safety Code

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.
 2. Place damaged equipment in first class, new operating condition; or, replace same as determined and directed by the COR. Such repair or replacement shall be at no additional cost to the Government.
 3. 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.

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

B. Cleanliness of Piping and Equipment Systems:

1. Exercise care in storage and handling of equipment and piping material to be incorporated in the work. Remove debris arising from cutting, threading and welding of piping.
2. Piping systems shall be flushed, blown or pigged as necessary to deliver clean systems.
3. Clean interior of all tanks prior to delivery for beneficial use by the Government.
4. Contractor shall be fully responsible for all costs, damage, and delay arising from failure to provide clean systems.

1.7 JOB CONDITIONS - WORK IN EXISTING BUILDING

- A. Building Operation: Government employees will be continuously operating and managing all facilities, including temporary facilities, that serve the medical center.
- B. Maintenance of Service: Schedule all work to permit continuous service as required by the medical center.
- C. 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 medical center. These non-critical periods are limited to between 8 pm and 5 am in the appropriate off-season (if applicable). Provide at least one week advance notice to the COR.
- D. Phasing of Work: Comply with all requirements shown on drawings or specified.
- 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. No storm water or ground water leakage permitted. Provide daily clean-up of construction and demolition debris on all floor surfaces and on all equipment being operated by VA.

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- F. Acceptance of Work for Government Operation: As new facilities are made available for operation and these facilities are of beneficial use to the Government, inspections will be made and tests will be performed. Based on the inspections, a list of contract deficiencies will be issued to the Contractor. After correction of deficiencies as necessary for beneficial use, the Contracting Officer will process necessary acceptance and the equipment will then be under the control and operation of Government personnel.
- G. Temporary Facilities: Refer to Article, TEMPORARY PIPING AND EQUIPMENT in this section.

PART 2 - PRODUCTS

2.1 2.1 FACTORY-ASSEMBLED PRODUCTS

- A. Provide maximum standardization of components to reduce spare part requirements.
- B. Manufacturers of equipment assemblies that include components made by others shall assume complete responsibility for final assembled unit.
1. All components of an assembled unit need not be products of same manufacturer.
 2. Constituent parts that are alike shall be products of a single manufacturer.
 3. Components shall be compatible with each other and with the total assembly for intended service.
 4. Contractor shall guarantee performance of assemblies of components, and shall repair or replace elements of the assemblies as required to deliver specified performance of the complete assembly.
- C. Components of equipment shall bear manufacturer's name and trademark, model number, serial number and performance data on a name plate securely affixed in a conspicuous place, or cast integral with, stamped or otherwise permanently marked upon the components of the equipment.
- D. Major items of equipment, which serve the same function, must be the same make and model. Exceptions will 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

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result will be a complete and fully operational plant that conforms to contract requirements.

2.3 BELT DRIVES

- A. Type: ANSI/RMA standard V-belts with proper motor pulley and driven sheave. Belts shall be constructed of reinforced cord and rubber.
- B. Dimensions, rating and selection standards: ANSI/RMA IP-20 and IP-21.
- C. Minimum Horsepower Rating: Motor horsepower plus recommended ANSI/RMA service factor (not less than 20 percent) in addition to the ANSI/RMA allowances for pitch diameter, center distance, and arc of contact.
- D. Maximum Speed: 25 m/s (5000 feet per minute).
- E. Adjustment Provisions: For alignment and ANSI/RMA standard allowances for installation and take-up.
- F. Drives may utilize a single V-Belt (any cross section) when it is the manufacturer's standard.
- G. Multiple Belts: Matched to ANSI/RMA specified limits by measurement on a belt measuring fixture. Seal matched sets together to prevent mixing or partial loss of sets. Replacement, when necessary, shall be an entire set of new matched belts.
- H. Sheaves and Pulleys:
 - 1. Material: Pressed steel, or close grained cast iron.
 - 2. Bore: Fixed or bushing type for securing to shaft with keys.
 - 3. Balanced: Statically and dynamically.
 - 4. Groove spacing for driving and driven pulleys shall be the same.
- I. Drive Types, Based on ARI 435:
 - 1. Provide adjustable-pitch or fixed-pitch drive as follows:
 - a. Fan speeds up to 1800 RPM: 7.5 kW (10 horsepower) and smaller.
 - b. Fan speeds over 1800 RPM: 2.2 kW (3 horsepower) and smaller.
 - 2. Provide fixed-pitch drives for drives larger than those listed above.
 - 3. The final fan speeds required to just meet the system CFM and pressure requirements, without throttling, shall be determined by adjustment of a temporary adjustable-pitch motor sheave or by fan law calculation if a fixed-pitch drive is used initially.

2.4 DRIVE GUARDS

- A. For machinery and equipment, provide guards as shown in AMCA 410 for belts, chains, couplings, pulleys, sheaves, shafts, gears and other

moving parts regardless of height above the floor to prevent damage to equipment and injury to personnel. Drive guards may be excluded where motors and drives are inside factory fabricated air handling unit casings.

- B. Pump shafts and couplings shall be fully guarded by a sheet steel guard, covering coupling and shaft but not bearings. Material shall be minimum 16-gage sheet steel; ends shall be braked and drilled and attached to pump base with minimum of four 6 mm (1/4-inch) bolts. Reinforce guard as necessary to prevent side play forcing guard onto couplings.
- C. V-belt and sheave assemblies shall be totally enclosed, firmly mounted, non-resonant. Guard shall be an assembly of minimum 22-gage sheet steel and expanded or perforated metal to permit observation of belts. 25 mm (one-inch) diameter hole shall be provided at each shaft centerline to permit speed measurement.
- D. Materials: Sheet steel, cast iron, expanded metal or wire mesh rigidly secured so as to be removable without disassembling pipe, duct, or electrical connections to equipment.
- E. Access for Speed Measurement: 25 mm (One inch) diameter hole at each shaft center.

2.5 LIFTING ATTACHMENTS

- 1. 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.

2.6 ELECTRIC MOTORS

- A. All material and equipment furnished and installation methods shall conform to the requirements of Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT; Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS; and, Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW). 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.

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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 shall be provided by the manufacturer of the driven equipment, such as pumps and fans, and shall be rated for 100 percent output performance. Multiple units of the same class of equipment, i.e. air handlers, fans, pumps, shall be product of a single manufacturer.
- C. Motors shall be premium efficiency type and be approved by the motor controller manufacturer. The controller-motor combination shall be guaranteed to provide full motor nameplate horsepower in variable frequency operation. Both driving and driven motor/fan sheaves shall be fixed pitch.
- D. Controller shall not add any current or voltage transients to the input AC power distribution system, DDC controls, sensitive medical equipment, etc., nor shall be affected from other devices on the AC power system.
- E. Controller shall be provided with the following operating features and accessories:
 - 1. Suitable for variable torque load.
 - 2. Provide thermal magnetic circuit breaker or fused switch with external operator and incoming line fuses. Unit shall be rated for minimum 30,000 AIC. Provide AC input line reactors (3% impedance) on incoming power line. Provide output line reactors on line between drive and motor for motors over 50 HP or where the distance between the breaker and motor exceeds 50 feet.

2.8 EQUIPMENT AND MATERIALS IDENTIFICATION

- A. Use symbols, nomenclature and equipment numbers specified, shown on the drawings and shown in the maintenance manuals.
- B. Interior (Indoor) Equipment: Engraved nameplates, with letters not less than 48 mm (3/16-inch) high of brass with black-filled letters, or rigid black plastic with white letters permanently fastened to the equipment. Identify unit components such as coils, filters, fans, etc.
- C. Painting pipes, pipe coverings, ducts, insulation, hangers, supports and other mechanical items and equipment exposed to view.
- D. Painting includes striping or markers and identity markings.

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- E. Exterior (Outdoor) Equipment: Brass nameplates, with engraved black filled letters, not less than 48 mm (3/16-inch) high riveted or bolted to the equipment.
- F. Control Items: Label all temperature and humidity sensors, controllers and control dampers. Identify and label each item as they appear on the control diagrams.
- G. Valve Tags and Lists:
 - 1. HVAC and Boiler Plant: Provide for all valves other than for equipment in Section 23 82 00, CONVECTION HEATING AND COOLING 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 6.4 mm(1/4-inch) for service designation on 19 gage 38 mm (1-1/2 inches) round brass disc, attached with brass "S" hook or brass chain.
 - 3. Valve lists: Typed or printed plastic coated card(s), sized 216 mm(8-1/2 inches) by 280 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.

2.9 FIRESTOPPING

- 1. 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, PLUMBING, AND BOILER PLANT INSULATION, for firestop pipe and duct insulation.

2.10 GALVANIZED REPAIR COMPOUND

- 1. Mil. Spec. DOD-P-21035B, paint form.

2.11 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 mm by 100 mm (2 by 4) 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

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- height 280 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-69. 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 102 mm (four inches) thick when approved by the COR for each job condition.
 3. Power-driven fasteners: Permitted in existing concrete or masonry not less than 102 mm (four inches) thick when approved by the COR for each job condition.
- E. Attachment to Steel Building Construction:
1. Welded attachment: MSS SP-58, Type 22.
 2. Beam clamps: MSS SP-58, Types 20, 21, 28 or 29. Type 23 C-clamp may be used for individual copper tubing up to 23mm (7/8-inch) outside diameter.
- F. Attachment to existing structure: Support from existing floor/roof frame.
- G. Attachment to Wood Construction: Wood screws or lag bolts.
- H. Hanger Rods: Hot-rolled steel, ASTM A36 or A575 for allowable load listed in MSS SP-58. For piping, provide adjustment means for controlling level or slope. Types 13 or 15 turn-buckles shall provide 38 mm (1-1/2 inches) minimum of adjustment and incorporate locknuts. All-thread rods are acceptable.
- I. Hangers Supporting Multiple Pipes (Trapeze Hangers): Galvanized, cold formed, lipped steel channel horizontal member, not less than 41 mm by 41 mm (1-5/8 inches by 1-5/8 inches), 2.7 mm (No. 12 gage), designed to accept special spring held, hardened steel nuts. Not permitted for steam supply and condensate piping.
1. Allowable hanger load: Manufacturers rating less 91kg (200 pounds).

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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 13mm (1/2-inch) galvanized steel bands, or preinsulated calcium silicate shield for insulated piping at each hanger.

J. Supports for Piping Systems:

1. Select hangers sized to encircle insulation on insulated piping. Refer to Section 23 07 11, HVAC, PLUMBING, AND BOILER PLANT INSULATION for insulation thickness. To protect insulation, provide Type 39 saddles for roller type supports or preinsulated calcium silicate shields. Provide Type 40 insulation shield or preinsulated calcium silicate shield at all other types of supports and hangers including those for preinsulated piping.
2. Piping Systems except High and Medium Pressure Steam (MSS SP-58):
 - a. Standard clevis hanger: Type 1; provide locknut.
 - b. Riser clamps: Type 8.
 - c. Wall brackets: Types 31, 32 or 33.
 - d. Roller supports: Type 41, 43, 44 and 46.
 - e. Saddle support: Type 36, 37 or 38.
 - f. Turnbuckle: Types 13 or 15. Preinsulate.
 - g. U-bolt clamp: Type 24.
 - h. Copper Tube:
 - 1) Hangers, clamps and other support material in contact with tubing shall be painted with copper colored epoxy paint, plastic coated or taped with non adhesive isolation tape to prevent electrolysis.
 - 2) For vertical runs use epoxy painted or plastic coated riser clamps.
 - 3) For supporting tube to strut: Provide epoxy painted pipe straps for copper tube or plastic inserted vibration isolation clamps.
 - 4) Insulated Lines: Provide pre-insulated calcium silicate shields sized for copper tube.
 - i. Supports for plastic or glass piping: As recommended by the pipe manufacturer with black rubber tape extending one inch beyond steel support or clamp.

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3. High and Medium Pressure Steam (MSS SP-58):

- a. Provide eye rod or Type 17 eye nut near the upper attachment.
- b. Piping 50 mm (2 inches) and larger: Type 43 roller hanger. For roller hangers requiring seismic bracing provide a Type 1 clevis hanger with Type 41 roller attached by flat side bars.
- c. Piping with Vertical Expansion and Contraction:
 - 1) Movement up to 20 mm (3/4-inch): Type 51 or 52 variable spring unit with integral turn buckle and load indicator.
 - 2) Movement more than 20 mm (3/4-inch): Type 54 or 55 constant support unit with integral adjusting nut, turn buckle and travel position indicator.

4. Convertor and Expansion Tank Hangers: May be Type 1 sized for the shell diameter. Insulation where required will cover the hangers.

K. Pre-insulated Calcium Silicate Shields:

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

2.12 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 100 mm (four inches) above finished floor and provide sealant for watertight joint.
 - 2. For blocked out floor openings: Provide 40 mm (1-1/2 inch) angle set in silicone adhesive around opening.
 - 3. For drilled penetrations: Provide 40 mm (1-1/2 inch) angle ring or square set in silicone adhesive around penetration.
- C. Penetrations are not allowed through beams or ribs, but may be installed in concrete beam flanges. Any deviation from these requirements must receive prior approval of COR.
- D. Sheet Metal, Plastic, or Moisture-resistant Fiber Sleeves: Provide for pipe passing through floors, interior walls, and partitions, unless brass or steel pipe sleeves are specifically called for below.
- E. Cast Iron or Zinc Coated Pipe Sleeves: Provide for pipe passing through exterior walls below grade. Make space between sleeve and pipe watertight with a modular or link rubber seal. Seal shall be applied at both ends of sleeve.
- F. Galvanized Steel 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.

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

2.13 DUCT PENETRATIONS

- A. Provide curbs for roof mounted piping, ductwork and equipment. Curbs shall be 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.

2.14 SPECIAL TOOLS AND LUBRICANTS

- A. Furnish, and turn over to the COR, tools not readily available commercially, that are required for disassembly or adjustment of equipment and machinery furnished.
- B. Grease Guns with Attachments for Applicable Fittings: One for each type of grease required for each motor or other equipment.
- C. Refrigerant Tools: Provide system charging/Evacuation equipment, gauges, fittings, and tools required for maintenance of furnished equipment.
- D. Tool Containers: Hardwood or metal, permanently identified for intended service and mounted, or located, where directed by the COR.
- E. Lubricants: A minimum of 0.95 L (one quart) of oil, and 0.45 kg (one pound) of grease, of equipment manufacturer's recommended grade and type, in unopened containers and properly identified as to use for each different application.

2.15 WALL, FLOOR AND CEILING PLATES

- A. Material and Type: Chrome plated brass or chrome plated steel, one piece or split type with concealed hinge, with set screw for fastening to pipe, or sleeve. Use plates that fit tight around pipes, cover openings around pipes and cover the entire pipe sleeve projection.
- B. Thickness: Not less than 2.4 mm (3/32-inch) for floor plates. For wall and ceiling plates, not less than 0.64 mm (0.025-inch) for up to 80 mm (3-inch pipe), 0.89 mm (0.035-inch) for larger pipe.
- C. Locations: Use where pipe penetrates floors, walls and ceilings in exposed locations, in finished areas only. Provide a watertight joint in spaces where brass or steel pipe sleeves are specified.

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2.16 ASBESTOS

1. Materials containing asbestos are not permitted.

PART 3 - EXECUTION

3.1 ARRANGEMENT AND INSTALLATION OF EQUIPMENT AND PIPING

- A. Coordinate location of piping, sleeves, inserts, hangers, ductwork and equipment. Locate piping, sleeves, inserts, hangers, ductwork and equipment clear of windows, doors, openings, light outlets, and other services and utilities. Prepare equipment layout drawings to coordinate proper location and personnel access of all facilities. Submit the drawings for review as required by Part 1. 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 gages and indicators shall be clearly visible by personnel standing on the floor or on permanent platforms. Do not reduce or change maintenance and operating space and access provisions that are shown on the drawings.
- C. Equipment and Piping Support: Coordinate structural systems necessary for pipe and equipment support with pipe and equipment locations to permit proper installation.
- D. Location of pipe sleeves, trenches and chases shall be accurately coordinated with equipment and piping locations.
- E. Cutting Holes:
 1. Cut holes through concrete and masonry by rotary core drill.
Pneumatic hammer, impact electric, and hand or manual hammer type drill will not be allowed, except as permitted by COR where working area space is limited.
 2. Locate holes to avoid interference with structural members such as beams or grade beams. Holes shall be laid out in advance and drilling done only after approval by COR. If the Contractor considers it necessary to drill through structural members, this matter shall be referred to COR for approval.

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3. Do not penetrate membrane waterproofing.

- F. Interconnection of Instrumentation or Control Devices: Generally, electrical and pneumatic interconnections are not shown but must be provided.
- G. Minor Piping: Generally, small diameter pipe runs from drips and drains, water cooling, and other service are not shown but must be provided.
- H. Electrical and Pneumatic Interconnection of Controls and Instruments: This generally not shown but must be provided. This includes interconnections of sensors, transmitters, transducers, control devices, control and instrumentation panels, instruments and computer workstations. Comply with NFPA-70.
- I. 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.
- J. Install gages, thermometers, valves and other devices with due regard for ease in reading or operating and maintaining said devices. Locate and position thermometers and gages to be easily read by operator or staff standing on floor or walkway provided. Servicing shall not require dismantling adjacent equipment or pipe work.
- K. Install steam piping expansion joints as per manufacturer's recommendations.
- L. Work in Existing Building:
1. Perform as specified in Article, OPERATIONS AND STORAGE AREAS, Article, ALTERATIONS, and Article, RESTORATION of the Section 01 00

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00, GENERAL REQUIREMENTS for relocation of existing equipment, alterations and restoration of existing building(s).

2. As specified in Section 01 00 00, GENERAL REQUIREMENTS, Article, OPERATIONS AND STORAGE AREAS, make alterations to existing service piping at times that will least interfere with normal operation of the facility.

3. Cut required openings through existing masonry and reinforced concrete using diamond core drills. Use of pneumatic hammer type drills, impact type electric drills, and hand or manual hammer type drills, will be permitted only with approval of the COR. Locate openings that will least effect structural slabs, columns, ribs or beams. Refer to the COR for determination of proper design for openings through structural sections and opening layouts approval, prior to cutting or drilling into structure. After COR's approval, carefully cut opening through construction no larger than absolutely necessary for the required installation.

M. Switchgear/Electrical Equipment Drip Protection: Every effort shall be made to eliminate the installation of pipe above electrical and 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 be located in the space equal to the width and depth of the equipment and extending from to a height of 1.8 m (6 ft.) above the equipment of to ceiling structure, whichever is lower (NFPA 70).

N. Inaccessible Equipment:

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

2. The term "conveniently accessible" is defined as capable of being reached without the use of ladders, or without climbing or crawling under or over obstacles such as motors, fans, pumps, belt guards, transformers, high voltage lines, piping, and ductwork.

3.2 TEMPORARY PIPING AND EQUIPMENT

A. Continuity of operation of existing facilities will generally require temporary installation or relocation of equipment and piping.

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

3.3 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 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. Rigging plan and methods shall be referred to COR for evaluation prior to actual work.
- G. Restore building to original condition upon completion of rigging 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. Drill or burn holes in structural steel only with the prior approval of the COR.

- B. Use of chain, wire or strap hangers; wood for blocking, stays and bracing; or, hangers suspended from piping above will not be permitted. Replace or thoroughly clean rusty products and paint with zinc primer.
- C. Use hanger rods that are straight and vertical. Turnbuckles for vertical adjustments may be omitted where limited space prevents use. Provide a minimum of 15 mm (1/2-inch) clearance between pipe or piping covering and adjacent work.
- D. HVAC Horizontal Pipe Support Spacing: Refer to MSS SP-69. Provide additional supports at valves, strainers, in-line pumps and other heavy components. Provide a support within one foot of each elbow.
- E. HVAC Vertical Pipe Supports:
 - 1. Up to 150 mm (6-inch pipe), 9 m (30 feet) long, bolt riser clamps to the pipe below couplings, or welded to the pipe and rests supports securely on the building structure.
 - 2. Vertical pipe larger than the foregoing, support on base elbows or tees, or substantial pipe legs extending to the building structure.
- F. Overhead Supports:
 - 1. The basic structural system of the building is designed to sustain the loads imposed by equipment and piping to be supported overhead.
 - 2. Provide steel structural members, in addition to those shown, of adequate capability to support the imposed loads, located in accordance with the final approved layout of equipment and piping.
 - 3. Tubing and capillary systems shall be supported in channel troughs.
- G. Floor Supports:
 - 1. Provide concrete bases, concrete anchor blocks and pedestals, and structural steel systems for support of equipment and piping. Anchor and dowel concrete bases and structural systems to resist forces under operating and seismic conditions (if applicable) without excessive displacement or structural failure.
 - 2. Do not locate or install bases and supports until equipment mounted thereon has been approved. Size bases to match equipment mounted thereon plus 50 mm (2 inch) excess on all edges. Boiler foundations shall have horizontal dimensions that exceed boiler base frame dimensions by at least 150 mm (6 inches) on all sides. Refer to

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structural drawings. 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.

3.5 MECHANICAL DEMOLITION

- A. Rigging access, other than indicated on the drawings, 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. Do not permit debris to accumulate in the area to the detriment of plant operation. 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 VA Medical Center, and Contractor shall follow all directives of the RE or COTR with regard to rigging, safety, fire safety, and maintenance of operations.
- C. Completely remove all piping, wiring, conduit, and other devices associated with the equipment not to be re-used in the new work. This includes all pipe, valves, fittings, insulation, and all hangers including the top connection and any fastenings to building structural systems. Seal all openings, after removal of equipment, pipes, ducts, and other penetrations in roof, walls, floors, in an approved manner and in accordance with plans and specifications where specifically covered. Structural integrity of the building system shall be

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maintained. Reference shall also be made to the drawings and specifications of the other disciplines in the project for additional facilities to be demolished or handled.

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

3.6 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. Use solvents, cleaning materials and methods recommended by the manufacturers for the specific tasks. Remove all rust prior to painting and from surfaces to remain unpainted. Repair scratches, scuffs, and abrasions prior to applying prime and finish coats.
 2. Material And Equipment Not To Be Painted Includes:
 - 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. Control and instrument panels shall be cleaned, damaged surfaces repaired, and shall be touched-up with matching paint obtained from panel manufacturer.

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4. Pumps, motors, steel and cast iron bases, and coupling guards shall be cleaned, and shall be touched-up with the same color as utilized by the pump manufacturer
5. Temporary Facilities: Apply paint to surfaces that do not have existing finish coats.
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 120 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 (375 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.

3.7 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.

3.8 IDENTITY PAINTING SCHEDULE:

- A. Identify designated service in new buildings or projects with extensive remodeling in accordance with ASME A13.1, unless specified otherwise, on exposed piping, piping above removable ceilings, piping in accessible pipe spaces, interstitial spaces, and piping behind access panels. For existing spaces where work is minor match existing.
 1. Legend may be identified using snap-on coil plastic markers or by paint stencil applications.
 2. Apply legends adjacent to changes in direction, on branches, where pipes pass through walls or floors, adjacent to operating accessories such as valves, regulators, strainers and cleanouts a

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minimum of 12.2 M (40 feet) apart on straight runs of piping.

Identification next to plumbing fixtures is not required.

3. Locate Legends clearly visible from operating position.
4. Use arrow to indicate direction of flow using black stencil paint.
5. Identify pipe contents with sufficient additional details such as temperature, pressure, and contents to identify possible hazard. Insert working pressure shown on construction documents where asterisk appears for High, Medium, and Low Pressure designations as follows:
 - a. High Pressure - 414 kPa (60 psig) and above.
 - b. Medium Pressure - 104 to 413 kPa (15 to 59 psig).
 - c. Low Pressure - 103 kPa (14 psig) and below.
6. Legend name in full or in abbreviated form as follows:

COLOR OF PIPING	EXPOSED PIPING	COLOR OF BACKGROUND	COLOR OF LETTERS	LEGEND ABBREVIATIONS
	Chilled Water Supply	Green	White	Ch. Wtr Sup
	Chilled Water Return	Green	White	Ch. Wtr Ret
	Refrigerant Liquid	Green	White	Refrigerant Liquid
	Refrigerant Suction	Green	White	Refrigerant Suction
	Compressed Air	Blue	White	Shop Air
	Air-Instrument Controls	Green	White	Air-Inst Cont
	Drain Line	Green	White	Drain
	High Pressure Steam	Green	White	H.P. _____*
	High Pressure Condensate Return	Green	White	H.P. Ret _____*
	Medium Pressure Steam	Green	White	M. P. Stm _____*
	Medium Pressure Condensate Return	Green	White	M.P. Ret _____*
	Low Pressure Steam	Green	White	L.P. Stm _____*
	Low Pressure Condensate Return	Green	White	L.P. Ret _____*
	Hot Water Heating Supply	Green	White	H. W. Htg Sup
	Hot Water Heating Return	Green	White	H. W. Htg Ret
	Gravity Condensate Return	Green	White	Gravity Cond Ret
	Pumped Condensate Return	Green	White	Pumped Cond Ret
	Chemical Feed	Green	White	Chem Feed
	Pumped Condensate	Green	White	Pump Cond
	Vent Line	Green	White	Vent

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3.9 MOTOR AND DRIVE ALIGNMENT

- A. Belt Drive: Set driving and driven shafts parallel and align so that the corresponding grooves are in the same plane.
- B. Direct-connect Drive: Securely mount motor in accurate alignment so that shafts are free from both angular and parallel misalignment when both motor and driven machine are operating at normal temperatures.

3.10 LUBRICATION

- A. Lubricate all devices requiring lubrication prior to initial operation. Field-check all devices for proper lubrication.
- B. Equip all devices with required lubrication fittings or devices. Provide a minimum of one liter (one quart) of oil and 0.5 kg (one pound) of grease of manufacturer's recommended grade and type for each different application; 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. Provide a separate grease gun with attachments for applicable fittings for each type of grease applied.
- D. All lubrication points shall be accessible without disassembling equipment, except to remove access plates.

3.11 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 specifications 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.

3.12 STARTUP AND TEMPORARY OPERATION

- A. Star- up equipment as described in equipment specifications. Verify that vibration is within specified tolerance 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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3.13 OPERATING AND PERFORMANCE TESTS

- A. Prior to the final inspection, perform required tests as specified in Section 01 00 00, GENERAL REQUIREMENTS 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 to the Government.
- C. When completion of certain work or system occurs at a time when final control settings and adjustments cannot be properly made to make performance tests, then make performance tests for heating systems and for cooling systems respectively during first actual seasonal use of respective systems following completion of work.

3.14 INSTRUCTIONS TO VA PERSONNEL

- A. Provide in accordance with Article, INSTRUCTIONS, of Section 01 00 00, GENERAL REQUIREMENTS.

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SECTION 23 05 12
GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION:

This section specifies the furnishing, installation and connection of motors for HVAC and steam generation equipment.

1.2 RELATED WORK:

- A. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA and SAMPLES.
- B. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- C. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
- D. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- E. Section 26 24 19, MOTOR-CONTROL CENTERS.
- F. Section 26 29 11, MOTOR CONTROLLERS.

1.3 SUBMITTALS:

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA and SAMPLES, and Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- B. Shop Drawings:
 - 1. Provide documentation to demonstrate compliance with drawings and specifications.
 - 2. Include 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.
- C. Manuals:
 - 1. Submit simultaneously with the shop drawings, companion copies of complete installation, maintenance and operating manuals, including technical data sheets and application data.
- D. Certification: Two weeks prior to final inspection, unless otherwise noted, submit four copies of the following certification to the Contracting Officer's Representative (COR):
 - 1. Certification that the motors have been applied, installed, adjusted, lubricated, and tested according to manufacturer published recommendations.

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- E. Completed System Readiness Checklists provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 23 08 00 COMMISSIONING OF HVAC SYSTEMS.

1.4 APPLICABLE PUBLICATIONS:

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. National Electrical Manufacturers Association (NEMA):
MG 1-2006 Rev. 1 2009 ..Motors and Generators
MG 2-2001 Rev. 1 2007...Safety Standard for Construction and Guide for
Selection, Installation and Use of Electric
Motors and Generators
- C. National Fire Protection Association (NFPA):
70-2014.....National Electrical Code (NEC)
- D. Institute of Electrical and Electronics Engineers (IEEE):
112-04.....Standard Test Procedure for Polyphase Induction
Motors and Generators
- E. American Society of Heating, Refrigerating and Air-Conditioning
Engineers (ASHRAE):
90.1-2013.....Energy Standard for Buildings Except Low-Rise
Residential Buildings

PART 2 - PRODUCTS

2.1 MOTORS:

- A. For alternating current, fractional and integral horsepower motors, NEMA Publications MG 1 and MG 2 shall apply.
- B. 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 as scheduled. Unless otherwise specified for a particular application, use electric motors with the following requirements.

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

1. Contractor's Option - Electrically Commutated motor (EC Type): Motor shall be brushless DC type specifically designed for applications with heavy duty ball bearings and electronic commutation. The motor shall be speed controllable down to 20% of full speed and 85% efficient at all speeds.

D. Poly-phase Motors: NEMA Design B, Squirrel cage, induction type.

1. Two Speed Motors: Each two-speed motor shall have two separate windings. Provide a time- delay (20 seconds minimum) relay for switching from high to low speed.

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 larger, connected to 480-volt systems: 460 volts.
- d. Motors connected to high voltage systems (Over 600V): Shall conform to NEMA Standards for connection to the nominal system voltage shown on the drawings.

F. Number of phases shall be as follows:

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

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G. Motors shall be designed for operating the connected loads continuously in a 40°C (104°F) environment, where the motors are installed, without exceeding the NEMA standard temperature rises for the motor insulation. If the motors exceed 40°C (104°F), the motors shall be rated for the actual ambient temperatures.

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

I. Motor Enclosures:

1. Shall be the NEMA types as specified and/or shown on the drawings.

2. Where the types of motor enclosures are not shown on the drawings, they shall be the NEMA types, which are most suitable for the environmental conditions where the motors are being installed.

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.

J. 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 time or cost 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:

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- a. Wiring material located where temperatures can exceed 71 degrees C (160 degrees F) shall be stranded copper with Teflon FEP insulation with jacket. This includes wiring on the boilers.
- b. Other wiring at boilers and to control panels shall be NFPA 70 designation THWN.
- c. Provide shielded conductors or wiring in separate conduits for all instrumentation and control systems where recommended by manufacturer of equipment.
- 4. Select motor sizes so that the motors do not operate into the service factor at maximum required loads on the driven equipment. Motors on pumps shall be sized for non-overloading at all points on the pump performance curves.
- 5. Motors utilized with variable frequency drives shall be rated "inverter-duty" per NEMA Standard, MG1, Part 31.4.4.2. Provide motor shaft grounding apparatus that will protect bearings from damage from stray currents.
- K. Additional requirements for specific motors, as indicated in the other sections listed in Article 1.2, shall also apply.
- L. Energy-Efficient Motors (Motor Efficiencies): All permanently wired polyphase motors of 746 Watts (1 HP) or more shall meet the minimum full-load efficiencies as indicated in the following table. Motors of 746 Watts or more with open, drip-proof or totally enclosed fan-cooled enclosures shall be NEMA premium efficiency type, unless otherwise indicated. Motors provided as an integral part of motor driven equipment are excluded from this requirement if a minimum seasonal or overall efficiency requirement is indicated for that equipment by the provisions of another section. Motors not specified as "premium efficiency" shall comply with the Energy Policy Act of 2005 (EPACT).

Minimum Premium Efficiencies Open Drip-Proof				Minimum Premium Efficiencies Totally Enclosed Fan-Cooled			
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%

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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%
37.3 (50)	94.1%	94.5%	93.0%	37.3 (50)	94.1%	94.5%	93.0%
44.8 (60)	94.5%	95.0%	93.6%	44.8 (60)	94.5%	95.0%	93.6%
56.9 (75)	94.5%	95.0%	93.6%	56.9 (75)	94.5%	95.4%	93.6%
74.6 (100)	95.0%	95.4%	93.6%	74.6 (100)	95.0%	95.4%	94.1%
93.3 (125)	95.0%	95.4%	94.1%	93.3 (125)	95.0%	95.4%	95.0%
112 (150)	95.4%	95.8%	94.1%	112 (150)	95.8%	95.8%	95.0%
149.2 (200)	95.4%	95.8%	95.0%	149.2 (200)	95.8%	96.2%	95.4%

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

PART 3 - EXECUTION

3.1 INSTALLATION:

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

3.2 FIELD TESTS

- A. Perform an electric insulation resistance Test using a megohmmeter on all motors after installation, before start-up. All shall test free from grounds.
- B. Perform Load test in accordance with ANSI/IEEE 112, Test Method B, to determine freedom from electrical or mechanical defects and compliance with performance data.
- C. Insulation Resistance: Not less than one-half meg-ohm between stator conductors and frame, to be determined at the time of final inspection.
- D. All test data shall be compiled into a report form for each motor and provided to the contracting officer or their representative.

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3.3 STARTUP AND TESTING

- A. The Commissioning Agent will observe startup and contractor testing of all equipment. Coordinate the startup and contractor testing schedules with COR and Commissioning Agent. Provide a minimum of 7 days prior notice.

3.4 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.
- B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

3.5 DEMONSTRATION AND TRAINING

- A. Provide services of manufacturer's technical representative for four hours to instruct VA personnel in operation and maintenance of units.
- B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS.

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SECTION 23 05 41

NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Noise criteria, seismic restraints for equipment, vibration tolerance and vibration isolation for HVAC and plumbing work.

1.2 RELATED WORK

- A. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA and SAMPLES.
B. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
C. Section 23 31 00, HVAC DUCTS and CASINGS.
D. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
E. Section 23 73 43, Custom, Indoor Central-Station Air-Handling Unit
F. Section 23 74 43, Custom, Outdoor Central-Station Air-Handling Unit

1.3 QUALITY ASSURANCE

- A. Refer to article, QUALITY ASSURANCE in specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
B. Noise Criteria:
1. Noise levels in all 8 octave bands due to equipment and duct systems shall not exceed following NC levels:

TYPE OF ROOM	NC LEVEL
Bathrooms and Toilet Rooms	40
Conference Rooms	35
Corridors (Nurse Stations)	40
Corridors(Public)	40
Dining Rooms, Food Services/ Serving	40
Examination Rooms	35
Laboratories (With Fume Hoods)	45 to 55
Lobbies, Waiting Areas	40
Locker Rooms	45
Offices, Large Open	40
Offices, Small Private	35
Patient Rooms	35
Treatment Rooms	35

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2. For equipment which has no sound power ratings scheduled on the plans, the contractor shall select equipment such that the foregoing noise criteria, local ordinance noise levels, and OSHA requirements are not exceeded. Selection procedure shall be in accordance with ASHRAE Fundamentals Handbook, Chapter 7, Sound and Vibration.
3. An allowance, not to exceed 5db, may be added to the measured value to compensate for the variation of the room attenuating effect between room test condition prior to occupancy and design condition after occupancy which may include the addition of sound absorbing material, such as, furniture. This allowance may not be taken after occupancy. The room attenuating effect is defined as the difference between sound power level emitted to room and sound pressure level in room.
4. In absence of specified measurement requirements, measure equipment noise levels three feet from equipment and at an elevation of maximum noise generation.

C. Seismic Restraint Requirements:

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

- D. 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

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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.

1.4 SUBMITTALS

- A. Submit in accordance with specification Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Manufacturer's Literature and Data:
 - 1. Vibration isolators:
 - a. Floor mountings
 - b. Hangers
 - c. Snubbers
 - d. Thrust restraints
 - 2. Bases.
 - 3. Acoustical enclosures.
- C. Isolator manufacturer shall furnish with submittal load calculations for selection of isolators, including supplemental bases, based on lowest operating speed of equipment supported.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE):
 - 1. 2009Fundamentals Handbook, Chapter 7, Sound and Vibration
- C. American Society for Testing and Materials (ASTM):
 - 1. A123/A123M-09Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
 - 2. A307-07bStandard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength
 - 3. D2240-05(2010)Standard Test Method for Rubber Property - Durometer Hardness
- D. Manufacturers Standardization (MSS):

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1. SP-58-2009Pipe Hangers and Supports-Materials, Design and Manufacture
- E. Occupational Safety and Health Administration (OSHA):
 1. 29 CFR 1910.95Occupational Noise Exposure
- F. American Society of Civil Engineers (ASCE):
 1. ASCE 7-10Minimum Design Loads for Buildings and Other Structures.
- G. American National Standards Institute / Sheet Metal and Air Conditioning Contractor's National Association (ANSI/SMACNA):
 1. 001-2008Seismic Restraint Manual: Guidelines for Mechanical Systems, 3rd Edition.
- H. International Code Council (ICC):
 1. 2009 IBCInternational Building Code.
- I. Department of Veterans Affairs (VA):
 1. H-18-8 2010Seismic Design Requirements.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Type of isolator, base, and minimum static deflection shall be as required for each specific equipment application as recommended by isolator or equipment manufacturer but subject to minimum requirements indicated herein.
- B. Elastometric Isolators shall comply with ASTM D2240 and be oil resistant neoprene with a maximum stiffness of 60 durometer and have a straight-line deflection curve.
- C. Exposure to weather: Isolator housings to be either hot dipped galvanized or powder coated to ASTM B117 salt spray testing standards. Springs to be powder coated or electro galvanized. All hardware to be electro galvanized. In addition provide limit stops to resist wind velocity. Velocity pressure established by wind shall be calculated in accordance with section 1609 of the International Building Code. A minimum wind velocity of 75 mph shall be employed.
- D. Uniform Loading: Select and locate isolators to produce uniform loading and deflection even when equipment weight is not evenly distributed.
- E. Color code isolators by type and size for easy identification of capacity.

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2.2 SEISMIC RESTRAINT REQUIREMENTS FOR EQUIPMENTS

- A. Bolt pad mounted equipment, without vibration isolators, to the floor or other support using ASTM A307 standard bolting material.
- B. Floor mounted equipment, with vibration Isolators: Type SS. Where Type N isolators are used provide channel frame base horizontal restraints bolted to the floor, or other support, on all sides of the equipment. Size and material required for the base shall be as recommended by the isolator manufacturer.
- C. On all sides of suspended equipment, provide bracing for rigid supports and provide restraints for resiliently supported equipment.

2.3 VIBRATION ISOLATORS

- A. Floor Mountings:
 - 1. 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 must be rigidly bolted to the equipment. Spring diameters shall be no less than 0.8 of the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal to 50 percent of the rated deflection. Mountings shall have ports for spring inspection. Provide an all directional neoprene cushion collar around the equipment bolt.

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4. Spring Isolators with Vertical Limit Stops (Type SP): Similar to spring isolators noted above, except include a vertical limit stop to limit upward travel if weight is removed and also to reduce movement and spring extension due to wind loads. Provide clearance around restraining bolts to prevent mechanical short circuiting.
5. 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. Washers and bushings shall be reinforced duck and neoprene. Size pads for a maximum load of 345 kPa (50 pounds per square inch).
6. Seismic Pad (Type DS): Pads shall be natural rubber / neoprene waffle with steel top plate and drilled for an anchor bolt. 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. Spring Position Hanger (Type HP): Similar to combination neoprene and spring hanger except hanger shall hold piping at a fixed elevation during installation and include a secondary adjustment feature to transfer load to spring while maintaining same position.
 3. Neoprene (Type HN): Vibration hanger shall contain a double deflection type neoprene isolation element. Hanger rod shall be separated from contact with hanger bracket by a neoprene grommet.
 4. Spring (Type HS): Vibration hanger shall contain a coiled steel spring in series with a neoprene grommet. Spring shall have a diameter not less than 0.8 of compressed operating spring height. Spring shall have a minimum additional travel of 50 percent between

design height and solid height. Spring shall permit a 15 degree angular misalignment without rubbing on hanger box.

5. Hanger supports for piping 50 mm (2 inches) and larger shall have a pointer and scale deflection indicator.
 6. Hangers used in seismic applications shall be provided with a neoprene and steel rebound washer installed $\frac{1}{4}$ ' clear of bottom of hanger housing in operation to prevent spring from excessive upward travel.
- C. Snubbers: Each spring mounted base shall have a minimum of four all-directional or eight two directional (two per side) seismic snubbers that are double acting. Elastomeric materials shall be shock absorbent neoprene bridge quality bearing pads, maximum 60 durometer, replaceable and have a minimum thickness of $\frac{1}{4}$ inch. Air gap between hard and resilient material shall be not less than $\frac{1}{8}$ inch nor more than $\frac{1}{4}$ inch. Restraints shall be capable of withstanding design load without permanent deformation.
- D. Thrust Restraints (Type THR): Restraints shall provide a spring element contained in a steel frame with neoprene pads at each end attachment. Restraints shall have factory preset thrust and be field adjustable to allow a maximum movement of $\frac{1}{4}$ inch when the fan starts and stops. Restraint assemblies shall include rods, angle brackets and other hardware for field installation.

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 $\frac{1}{12}$ of longest base dimension but not less than 4 inches. Where rails are used with neoprene mounts for small fans or close coupled pumps, extend rails to compensate overhang of housing.
- B. Integral Structural Steel Base (Type B): Design base with isolator brackets to reduce mounting height of equipment which require a complete supplementary rigid base. To assure adequate stiffness, height of members shall be a minimum of $\frac{1}{12}$ of longest base dimension, but not less than 4 inches.

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- C. Inertia Base (Type I): Base shall be a reinforced concrete inertia base. Pour concrete into a welded steel channel frame, incorporating pre-located equipment anchor bolts and pipe sleeves. Level the concrete to provide a smooth uniform bearing surface for equipment mounting. Provide grout under uneven supports. Channel depth shall be a minimum of 1/12 of longest dimension of base but not less than six inches. Form shall include 1/2-inch reinforcing bars welded in place on minimum of eight inch centers running both ways in a layer 1-1/2 inches above bottom. Use height saving brackets in all mounting locations. Weight of inertia base shall be equal to or greater than weight of equipment supported to provide a maximum peak-to-peak displacement of 1/16 inch.
- D. Curb Mounted Isolation Base (Type CB): Fabricate from aluminum to fit on top of standard curb with overlap to allow water run-off and have wind and water seals which shall not interfere with spring action. Provide resilient snubbers with 1/4 inch clearance for wind resistance. Top and bottom bearing surfaces shall have sponge type weather seals. Integral spring isolators shall comply with Spring Isolator (Type S) requirements.

2.5 SOUND ATTENUATING UNITS

1. Refer to specification Section 23 31 00, HVAC DUCTS and CASINGS.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Vibration Isolation:
1. No metal-to-metal contact will be permitted between fixed and floating parts.
 2. Connections to Equipment: Allow for deflections equal to or greater than equipment deflections. Electrical, drain, piping connections, and other items made to rotating or reciprocating equipment (pumps, compressors, etc.) which rests on vibration isolators, shall be isolated from building structure for first three hangers or supports with a deflection equal to that used on the corresponding equipment.
 3. Common Foundation: Mount each electric motor on same foundation as driven machine. Hold driving motor and driven machine in positive rigid alignment with provision for adjusting motor alignment and

belt tension. Bases shall be level throughout length and width.

Provide shims to facilitate pipe connections, leveling, and bolting.

4. Provide heat shields where elastomers are subject to temperatures over 100 degrees F.
5. Extend bases for pipe elbow supports at discharge and suction connections at pumps. Pipe elbow supports shall not short circuit pump vibration to structure.
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.

- B. Inspection and Adjustments: Check for vibration and noise transmission through connections, piping, ductwork, foundations, and walls. Adjust, repair, or replace isolators as required to reduce vibration and noise transmissions to specified levels.

3.2 ADJUSTING

- A. Adjust vibration isolators after piping systems are filled and equipment is at operating weight.
- B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
- C. Attach thrust limits at centerline of thrust and adjust to a maximum of $\frac{1}{4}$ inch movement during start and stop.
- D. Adjust active height of spring isolators.
- E. Adjust snubbers according to manufacturer's recommendations.
- F. Adjust seismic restraints to permit free movement of equipment within normal mode of operation.
- G. Torque anchor bolts according to equipment manufacturer's recommendations to resist seismic forces.

3.3 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.

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- B. Components provided under this section of the specification will be tested as part of a larger system. Refer to section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

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SELECTION GUIDE FOR VIBRATION ISOLATORS

EQUIPMENT		ON GRADE			20FT FLOOR SPAN			30FT FLOOR SPAN			40FT FLOOR SPAN			50FT FLOOR SPAN		
		BASE TYPE	ISOL TYPE	MIN DEFL	BASE TYPE	ISOL TYPE	MIN DEFL	BASE TYPE	ISOL TYPE	MIN DEFL	BASE TYPE	ISOL TYPE	MIN DEFL	BASE TYPE	ISOL TYPE	MIN DEFL
COMPRESSORS AND VACUUM PUMPS																
UP THROUGH 1-1/2 HP		---	D,L, W	0.8	----	D,L, W	0.8	---	D,L, W	1.5	---	D,L, W	1.5	---	D,L, W	---
2 HP AND OVER:																
500 - 750 RPM		---	D	0.8	---	S	0.8	---	S	1.5	---	S	1.5	---	S	2.5
750 RPM & OVER		---	D	0.8	---	S	0.8	---	S	1.5	---	S	1.5	---	S	2.5
PUMPS																
CLOSE COUPLED	UP TO 1-1/2 HP	---	---	---	---	D,L, W	---	---	D,L, W	---	---	D,L, W	---	---	D,L, W	---
	2 HP & OVER	---	---	---	I	S	0.8	I	S	1.5	I	S	1.5	I	S	2.0
LARGE INLINE	Up to 25 HP	---	---	---	---	S	0.75	---	S	1.50	---	S	1.50	---	---	NA
	26 HP THRU 30 HP	---	---	---	---	S	1.0	---	S	1.50	---	S	2.50	---	---	NA
	UP TO 10 HP	---	---	---	---	D,L, W	---	---	D,L, W	---	---	D,L, W	---	---	D,L, W	---

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EQUIPMENT		ON GRADE			20FT FLOOR SPAN			30FT FLOOR SPAN			40FT FLOOR SPAN			50FT FLOOR SPAN		
		BASE TYPE	ISOL TYPE	MIN DEFL	BASE TYPE	ISOL TYPE	MIN DEFL	BASE TYPE	ISOL TYPE	MIN DEFL	BASE TYPE	ISOL TYPE	MIN DEFL	BASE TYPE	ISOL TYPE	MIN DEFL
BASE MOUNTED	15 HP THRU 40 HP	I	S	1.0	I	S	1.0	I	S	2.0	I	S	2.0	I	S	2.0
	50 HP & OVER	I	S	1.0	I	S	1.0	I	S	2.0	I	S	2.5	I	S	2.5
ROOF FANS																
ABOVE OCCUPIED AREAS:																
5 HP & OVER		---	---	---	CB	S	1.0	CB	S	1.0	CB	S	1.0	CB	S	1.0
CENTRIFUGAL FANS																
UP TO 50 HP:																
UP TO 200 RPM		B	N	0.3	B	S	2.5	B	S	2.5	B	S	3.5	B	S	3.5
201 - 300 RPM		B	N	0.3	B	S	2.0	B	S	2.5	B	S	2.5	B	S	3.5
301 - 500 RPM		B	N	0.3	B	S	2.0	B	S	2.0	B	S	2.5	B	S	3.5
501 RPM & OVER		B	N	0.3	B	S	2.0	B	S	2.0	B	S	2.0	B	S	2.5
60 HP & OVER:																
UP TO 300 RPM		B	S	2.0	I	S	2.5	I	S	3.5	I	S	3.5	I	S	3.5
301 - 500 RPM		B	S	2.0	I	S	2.0	I	S	2.5	I	S	3.5	I	S	3.5
501 RPM & OVER		B	S	1.0	I	S	2.0	I	S	2.0	I	S	2.5	I	S	2.5

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EQUIPMENT	ON GRADE			20FT FLOOR SPAN			30FT FLOOR SPAN			40FT FLOOR SPAN			50FT FLOOR SPAN		
	BASE TYPE	ISOL TYPE	MIN DEFL	BASE TYPE	ISOL TYPE	MIN DEFL	BASE TYPE	ISOL TYPE	MIN DEFL	BASE TYPE	ISOL TYPE	MIN DEFL	BASE TYPE	ISOL TYPE	MIN DEFL
AIR HANDLING UNIT PACKAGES															
SUSPENDED:															
UP THRU 5 HP	---	---	---	---	H	1.0	---	H	1.0	---	H	1.0	---	H	1.0
7-1/2 HP & OVER:															
UP TO 500 RPM	---	---	---	---	H, THR	1.5	---	H, THR	2.5	---	H, THR	2.5	---	H, THR	2.5
501 RPM & OVER	---	---	---	---	H, THR	0.8	---	H, THR	0.8	---	H,TH R	0.8	---	H,TH R	2.0
FLOOR MOUNTED:															
UP THRU 5 HP	---	D	---	---	S	1.0	---	S	1.0	---	S	1.0	---	S	1.0
7-1/2 HP & OVER:															
UP TO 500 RPM	---	D	---	R	S, THR	1.5	R	S, THR	2.5	R	S, THR	2.5	R	S, THR	2.5
501 RPM & OVER	---	D	---	---	S, THR	0.8	---	S, THR	0.8	R	S, THR	1.5	R	S, THR	2.0
HEAT PUMPS															
ALL	---	S	0.75	---	S	0.75	---	S	0.75	CB	S	1.5	---	---	NA
CONDENSING UNITS															
ALL	---	SS	0.25	---	SS	0.75	---	SS	1.5	CB	SS	1.5	---	---	NA

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

PART 1 - GENERAL

1.1 DESCRIPTION

A. Testing, adjusting, and balancing (TAB) of heating, ventilating and air conditioning (HVAC) systems. TAB includes the following:

1. Planning systematic TAB procedures.
2. Design Review Report.
3. 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. Vibration and sound measurements.
8. Recording and reporting results.

B. Definitions:

1. Basic TAB used in this Section: Chapter 37, "Testing, Adjusting and Balancing" of 2007 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. Hydronic Systems: Includes chilled water, heating hot water.
6. Air Systems: Includes all outside air, supply air, return air, exhaust air and relief air systems.
7. 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 23 05 11, COMMON WORK RESULTS FOR HVAC: General Mechanical Requirements.
- B. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT: Noise and Vibration Requirements.

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- C. Section 23 07 11, HVAC, PLUMBING, AND BOILER PLANT INSULATION: Piping and Equipment Insulation.
- D. Section 23 31 00, HVAC DUCTS AND CASINGS: Duct Leakage.
- E. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC: Controls and Instrumentation Settings.
- F. Section 23 82 16, AIR COILS
- G. Section 23 82 00, CONVECTION HEATING AND COOLING UNITS
- H. Section 23 73 43, CUSTOM, INDOOR, CENTRAL-STATION AIR-HANDLING UNITS
- I. Section 23 74 43, CUSTOM, OUTDOOR, CENTRAL-STATION AIR-HANDLING UNITS
- J. Section 23 34 00, HVAC FANS
- K. Section 23 21 23, HYDRONIC PUMPS
- L. Section 23 22 23, STEAM CONDENSATE PUMPS
- M. Section 23 37 00, AIR OUTLETS AND INLETS
- N. Section 23 21 13, HYDRONIC PIPING
- O. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS. Requirements for commissioning, systems readiness checklists, and training
- P. Section 23 05 12 GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT

1.3 QUALITY ASSURANCE

- A. Refer to Articles, Quality Assurance and Submittals, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC 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 or certified by the NEBB 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 Contracting Officers Representative (COR) and submit another TAB firm for approval. Any agency that has been the subject of disciplinary action by either the AABC or the NEBB within

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the five years preceding Contract Award shall not be eligible to perform any work related to the TAB. All work performed in this Section and in other related Sections by the TAB agency shall be considered invalid if the TAB agency loses its certification prior to Contract completion, and the successor agency's review shows unsatisfactory work performed by the predecessor agency.

3. TAB Specialist: The TAB specialist shall be either a member of AABC 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 years preceding Contract Award shall not be eligible to perform any duties related to the HVAC systems, including TAB. All work specified in this Section and in other related Sections performed by the TAB specialist shall be considered invalid if the TAB Specialist loses its certification prior to Contract completion and must be performed by an approved successor.
4. TAB Specialist shall be identified by the General Contractor within 60 days after the notice to proceed. The TAB specialist will be coordinating, scheduling and reporting all TAB work and related activities and will provide necessary information as required by the COR. The responsibilities would specifically include:
 - a. Shall directly supervise all TAB work.
 - b. Shall sign the TAB reports that bear the seal of the TAB standard. The reports shall be accompanied by report forms and schematic drawings required by the TAB standard, AABC or NEBB.
 - c. Would follow all TAB work through its satisfactory completion.
 - d. Shall provide final markings of settings of all HVAC adjustment devices.
 - e. Permanently mark location of duct test ports.
5. All TAB technicians performing actual TAB work shall be experienced and must have done satisfactory work on a minimum of 3 projects

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comparable in size and complexity to this project. Qualifications must be certified by the TAB agency in writing. The lead technician shall be certified by AABC or NEBB.

C. Test Equipment Criteria: Instrumentation shall meet accuracy and calibration requirements established by AABC National Standards or NEBB Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems and instrument manufacturer. Provide calibration history of instruments to be used for test and balance purpose.

D. Tab Criteria:

1. One or more of the applicable AABC, NEBB or SMACNA publications, supplemented by ASHRAE Handbook "HVAC Applications" Chapter 36, 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 ASHRAE Handbook "HVAC Applications", Chapter 36, as a guideline. Air Filter resistance during tests, artificially imposed if necessary, shall be at least 100 percent of manufacturer recommended change over pressure drop values for pre-filters and after-filters.

- a. Air handling unit and all other fans, cubic meters/min (cubic feet per minute): Minus 0 percent to plus 10 percent.
- b. Air terminal units (maximum values): Minus 2 percent to plus 10 percent.
- c. Exhaust hoods/cabinets: 0 percent to plus 10 percent.
- d. Minimum outside air: 0 percent to plus 10 percent.
- e. Individual room air outlets and inlets, and air flow rates not mentioned above: Minus 5 percent to plus 10 percent except if the air to a space is 100 CFM or less the tolerance would be minus 5 to plus 5 percent.
- f. Heating hot water pumps and hot water coils: Minus 5 percent to plus 5 percent.
- g. Chilled water and condenser water pumps: Minus 0 percent to plus 5 percent.
- h. Chilled water coils: Minus 0 percent to plus 5 percent.

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3. Systems shall be adjusted for energy efficient operation as described in PART 3.
4. Typical TAB procedures and results shall be demonstrated to the COR for one air distribution system (including all fans, three terminal units, three rooms randomly selected by the COR) and one hydronic system (pumps and three 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.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Submit names and qualifications of TAB agency and TAB specialists within 60 days after the notice to proceed. Submit information on three recently completed projects and a list of proposed test equipment.
- C. For use by the COR staff, submit one complete set of applicable AABC or NEBB publications that will be the basis of TAB work.
- D. Submit Following for Review and Approval:
 1. Design Review Report 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.
- E. Prior to request for Final or Partial Final inspection, submit completed Test and Balance report for the area.

1.5 APPLICABLE PUBLICATIONS

- A. The following publications form a part of this specification to the extent indicated by the reference thereto. In text the publications are referenced to by the acronym of the organization.

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- B. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE):
 - 2007 HVAC Applications ASHRAE Handbook, Chapter 37, Testing, Adjusting, and Balancing and Chapter 47, Sound and Vibration Control
- C. Associated Air Balance Council (AABC):
 - 2002 AABC National Standards for Total System Balance
- D. National Environmental Balancing Bureau (NEBB):
 - 7th Edition 2005Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems
 - 2nd Edition 2006Procedural Standards for the Measurement of Sound and Vibration
 - 3rd Edition 2009Procedural Standards for Whole Building Systems Commissioning of New Construction
- E. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):
 - 3rd Edition 2002HVAC SYSTEMS Testing, Adjusting and Balancing

PART 2 - PRODUCTS

2.1 PLUGS

- A. Provide plastic plugs to seal holes drilled in ductwork for test purposes.

2.2 INSULATION REPAIR MATERIAL

- A. See Section 23 07 11, HVAC and BOILER PLANT INSULATION Provide for repair of insulation removed or damaged for TAB work.

PART 3 - EXECUTION

3.1 GENERAL

- A. Refer to TAB Criteria in Article, Quality Assurance.
- B. Obtain applicable contract documents and copies of approved submittals for HVAC equipment and automatic control systems.

3.2 DESIGN REVIEW REPORT

- A. The TAB Specialist shall review the Contract Plans and specifications and advise the COR of any design deficiencies that would prevent the HVAC systems from effectively operating in accordance with the sequence of operation specified or prevent the effective and accurate TAB of the system. The TAB Specialist shall provide a report individually listing

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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 is to be done after air distribution equipment is on site and duct installation has begun, but well in advance of performance testing and balancing work. The purpose of the inspection is to identify and report deviations from design and ensure that systems will be ready for TAB at the appropriate time.
- C. Reports: Follow check list format developed by AABC, NEBB or SMACNA, supplemented by narrative comments, with emphasis on air handling units and fans. Check for conformance with submittals. Verify that diffuser and register sizes are correct. Check air terminal unit installation including their duct sizes and routing.

3.4 DUCT AIR LEAKAGE TEST REPORT

- A. TAB Agency shall perform the leakage test as outlined in "Duct leakage Tests and Repairs" in Section 23 31 00, HVAC DUCTS and CASINGS for TAB agency's role and responsibilities in witnessing, recording and reporting of deficiencies.

3.5 SYSTEM READINESS REPORT

- A. The TAB Contractor shall measure existing air and water flow rates associated with existing systems utilized to serve renovated areas as indicated on drawings. Submit report of findings to COR.
- B. 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 Commissioning Agent.
- C. Verify that all items such as ductwork piping, ports, terminals, connectors, etc., that is required for TAB are installed. Provide a report to the COR.

3.6 TAB REPORTS

- A. Submit an intermediate report for 25 percent of systems and equipment tested and balanced to establish satisfactory test results.

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- B. The TAB contractor shall provide raw data immediately in writing to the COR if there is a problem in achieving intended results before submitting a formal report.
- C. If over 20 percent of readings in the intermediate report fall outside the acceptable range, the TAB report shall be considered invalid and all contract TAB work shall be repeated and re-submitted for approval at no additional cost to the owner.
- D. Do not proceed with the remaining systems until intermediate report is approved by the COR.

3.7 TAB PROCEDURES

- A. Tab shall be performed in accordance with the requirement of the Standard under which TAB agency is certified by either AABC or NEBB.
- B. General: TAB report testing shall not commence until all point-to-point testing of DDC automatic controls is complete and all trends for control points affected by TAB have been established. During TAB all related system components shall be in full operation. Fan and pump rotation, motor loads and equipment vibration shall be checked and corrected as necessary before proceeding with TAB. Set controls and/or block off parts of distribution systems to simulate design operation of variable volume air or water systems for test and balance work.
- C. Coordinate TAB procedures with existing systems and any phased construction completion requirements for the project. Provide TAB reports for pre-construction air and water flow rate and for each phase of the project prior to partial final inspections of each phase of the project. Return existing areas outside the work area to pre constructed conditions.
- D. Allow 30 days time in construction schedule for TAB and submission of all reports for an organized and timely correction of deficiencies.
- E. Air Balance and Equipment Test: Include air handling units, fans, air outlets/inlets, ductwork for hot deck supply, cold deck supply, return air, and exhaust air.
 - 1. Adjust fan speeds to provide design air flow. V-belt drives, including fixed pitch pulley requirements, are specified in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

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2. Test and balance systems in all specified modes of operation, including variable volume, economizer, and fire emergency modes. Verify that dampers and other controls function properly.
3. Dual Duct systems:
 - a. Coordinate TAB, including system volumetric controls, with Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
 - b. Balance air distribution from air handling unit on maximum cooling scheduled in cubic meters per minute (cubic feet per minute). Reset room thermostats and check air handling unit operation from maximum to minimum cooling, to the heating mode, and back to cooling. Record and report the heating coil leaving air temperature when the air handling unit is in the maximum heating mode. Balance air handling unit during Economizer cycle mode of operation. Record and report outdoor air flow rates under all operating conditions (The test shall demonstrate that the minimum outdoor air ventilation rate shall remain constant under all operating conditions).
 - c. Adjust operating pressure control setpoint to maintain the design flow to each space with the lowest setpoint.
4. Record final measurements for air handling equipment performance data sheets.
5. VRV System:
 - a. Perform Check Operation testing as outlined by the manufacturer's installation instructions to determine all valves are open, wiring is correct, refrigerant charge is correct.
 - b. After all installation work is complete and Check Operation procedure has been satisfied, perform Test Run procedure as recommended by the manufacturer. Test Run procedure shall be performed when the outdoor temperature is above 23 °F and below 75 °F so both heating and cooling modes of operation may be checked.
 - c. Record the date and all settings upon completion of required testing on the manufacturer's label provided and affix the

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label(s) to the back side of the front panel of the outdoor unit.

F. Water Balance and Equipment Test: Include circulating pumps, convertors, coils, coolers and condensers:

1. Adjust flow rates for equipment. Set coils and evaporator to values on equipment submittals, if different from values on contract drawings.
2. Primary-secondary (variable volume) systems: Coordinate TAB with Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC. Balance systems at design water flow and then verify that variable flow controls function as designed.
3. Record final measurements for hydronic equipment on performance data sheets. Include entering and leaving water temperatures for heating and cooling coils, and for convertors. Include entering and leaving air temperatures (DB/WB for cooling coils) for air handling units and preheat coils. Make air and water temperature measurements at the same time.

3.8 VIBRATION TESTING

- A. Furnish instruments and perform vibration measurements as specified in Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT. Field vibration balancing is specified in Section 23 05 11, COMMON WORK RESULTS FOR HVAC. Provide measurements for all rotating HVAC equipment of 373 watts (1/2 horsepower) and larger, including centrifugal/screw compressors, cooling towers, pumps, fans and motors.
- B. Record initial measurements for each unit of equipment on test forms and submit a report to the COR. Where vibration readings exceed the allowable tolerance Contractor shall be directed to correct the problem. The TAB agency shall verify that the corrections are done and submit a final report to the COR.

3.9 SOUND TESTING

- A. Perform and record required sound measurements in accordance with Paragraph, QUALITY ASSURANCE in Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.
 1. Take readings in rooms, approximately three percent of all rooms. The COR may designate the specific rooms to be tested.

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- B. Take measurements with a calibrated sound level meter and octave band analyzer of the accuracy required by AABC or NEBB.
- C. Sound reference levels, formulas and coefficients shall be according to ASHRAE Handbook, "HVAC Applications", Chapter 46, SOUND AND VIBRATION CONTROL.
- D. Determine compliance with specifications as follows:
1. When sound pressure levels are specified, including the NC Criteria in Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT:
 - a. Reduce the background noise as much as possible by shutting off unrelated audible equipment.
 - b. Measure octave band sound pressure levels with specified equipment "off."
 - c. Measure octave band sound pressure levels with specified equipment "on."
 - d. Use the DIFFERENCE in corresponding readings to determine the sound pressure due to equipment.

DIFFERENCE:	0	1	2	3	4	5 to 9	10 or More
FACTOR:	10	7	4	3	2	1	0

Sound pressure level due to equipment equals sound pressure level with equipment "on" minus FACTOR.

- e. Plot octave bands of sound pressure level due to equipment for typical rooms on a graph which also shows noise criteria (NC) curves.
2. When sound power levels are specified:
 - a. Perform steps 1.a. thru 1.d., as above.
 - b. For indoor equipment: Determine room attenuating effect, i.e., difference between sound power level and sound pressure level. Determined sound power level will be the sum of sound pressure level due to equipment plus the room attenuating effect.
 - c. For outdoor equipment: Use directivity factor and distance from noise source to determine distance factor, i.e., difference between sound power level and sound pressure level. Measured sound power level will be the sum of sound pressure

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level due to equipment plus the distance factor. Use 10 meters (30 feet) for sound level location.

3. Where sound pressure levels are specified in terms of dB(A), measure sound levels using the "A" scale of meter. Single value readings will be used instead of octave band analysis.

E. Where measured sound levels exceed specified level, the installing contractor or equipment manufacturer shall take remedial action approved by the COR and the necessary sound tests shall be repeated.

F. Test readings for sound testing could go higher than 15 percent if determination is made by the COR based on the recorded sound data.

3.10 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.

3.11 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.

3.12 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.

3.13 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.

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B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

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SECTION 23 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 REQUIREMENTS. A Commissioning Agent (CxA) appointed by the VA will manage the commissioning process.

1.2 RELATED WORK

- A. Section 01 00 00 GENERAL REQUIREMENTS.
- B. Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS.
- C. Section 01 33 23 SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

1.3 SUMMARY

- A. This Section includes requirements for commissioning the Facility exterior closure, related subsystems and related equipment. This Section supplements the general requirements specified in Section 01 91 00 General Commissioning Requirements.
- B. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for more details regarding processes and procedures as well as roles and responsibilities for all Commissioning Team members.

1.4 DEFINITIONS

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

1.5 COMMISSIONED SYSTEMS

- A. Commissioning of a system or systems specified in Division 23 is part of the construction process. Documentation and testing of these

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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 23, is required in cooperation with the VA and the Commissioning Agent.

- B. The Facility exterior closure systems commissioning will include the systems listed in Section 01 19 00 General Commissioning Requirements:

1.6 SUBMITTALS

- A. The commissioning process requires review of selected Submittals that pertain to the systems to be commissioned. The Commissioning Agent will provide a list of submittals that will be reviewed by the Commissioning Agent. This list will be reviewed and approved by the VA prior to forwarding to the Contractor. Refer to Section 01 33 23 SHOP DRAWINGS, PRODUCT DATA, and SAMPLES for further details.
- B. The commissioning process requires Submittal review simultaneously with engineering review. Specific submittal requirements related to the commissioning process are specified in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 CONSTRUCTION INSPECTIONS

- A. Commissioning of 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 19 00 and the Commissioning plan to schedule HVAC systems inspections as required to support 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

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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 Contracting Officer's Representative (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

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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 19 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 23 Sections for additional Contractor training requirements.

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SECTION 23 09 23
DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Provide (a) 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. Use of existing hardware that meets this specification is acceptable. Include all engineering, programming, controls and installation materials, installation labor, commissioning and start-up, training, final project documentation and warranty.
1. The direct-digital control system(s) shall consist of high-speed, peer-to-peer network of DDC controllers, a control system server, and an Engineering Control Center. Provide a remote user using a standard web browser to access the control system graphics and change adjustable setpoints with the proper password.
 2. The direct-digital control system(s) shall be native BACnet. All new workstations, controllers, devices and components shall be listed by BACnet Testing Laboratories. All new workstations, controller, devices and components shall be accessible using a Web browser interface and shall communicate exclusively using the ASHRAE Standard 135 BACnet communications protocol without the use of gateways, unless otherwise allowed by this Section of the technical specifications, specifically shown on the design drawings and specifically requested otherwise by the VA.
 - a. If used, gateways shall support the ASHRAE Standard 135 BACnet communications protocol.
 - 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,

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calibration, documentation, submittals, testing, verification, training services, permits and licenses, transportation, shipping, handling, administration, supervision, management, insurance, Warranty, specified services and items required for complete and fully functional Controls Systems.

4. The control systems shall be designed such that each mechanical system shall operate under stand-alone mode. The contractor administered by this Section of the technical specifications shall provide controllers for each mechanical system. In the event of a network communication failure, or the loss of any other controller, the control system shall continue to operate independently. Failure of the ECC shall have no effect on the field controllers, including those involved with global strategies.
 5. The control system shall accommodate 1 Engineering Control Center(s) and the control system shall accommodate 5 web-based Users simultaneously, and the access to the system should be limited only by operator password.
- B. Some products are furnished but not installed by the contractor administered by this Section of the technical specifications. The contractor administered by this Section of the technical specifications shall formally coordinate in writing and receive from other contractors formal acknowledgements in writing prior to submission the installation of the products. These products include 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

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submission the procurement of the products. These products include the following:

1. Factory-furnished accessory thermostats and sensors furnished with unitary or de-centralized 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. The contractor administered by this Section of the technical specifications shall formally coordinate in writing and receive from other contractors formal acknowledgements in writing prior to submission the particulars of the products. These products include 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. Terminal units' velocity sensors
 3. Unitary HVAC equipment (split systems) controls. These include:
 - a. Setpoint reset.
 - b. Time of day indexing.
 - c. Status alarm.

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
Controllers for terminal units	23 09 23	23	23 09 23	26
LAN conduits and raceway	23 09 23	23 09 23	N/A	N/A
Automatic dampers (not furnished with equipment)	23 09 23	23	N/A	N/A
Automatic damper actuators	23 09 23	23 09 23	23 09 23	23 09 23

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Work/Item/System	Furnish	Install	Low Voltage Wiring	Line Power
Manual valves	23	23	N/A	N/A
Automatic valves	23 09 23	23	23 09 23	23 09 23
Pipe insertion devices and taps, flow and pressure stations.	23	23	N/A	N/A
Thermowells	23 09 23	23	N/A	N/A
Current Switches	23 09 23	23 09 23	23 09 23	N/A
Control Relays	23 09 23	23 09 23	23 09 23	N/A
Power distribution system monitoring interfaces	23 09 23	23 09 23	23 09 23	26
All control system nodes, equipment, housings, enclosures and panels.	23 09 23	23 09 23	23 09 23	26
Smoke detectors	28 31 00	28 31 00	28 31 00	28 31 00
Fire/Smoke Dampers	23	23	28 31 00	28 31 00
Smoke Dampers	23	23	28 31 00	28 31 00
Fire Dampers	23	23	N/A	N/A
VFDs	23 09 23	26	23 09 23	26
Elevator Machine Room A/C Unit field-mounted controls	23	23	16	26
Control system interface with Elevator Machine Room A/C controls	23 09 23	23 09 23	23 09 23	26
Elevator Machine Room A/C unit controls interface with control system	23	23 09 23	23 09 23	26
Fire Alarm shutdown relay interlock wiring	28	28	28	26
Control system monitoring of fire alarm smoke control relay	28	28	23 09 23	28
Fire-fighter's smoke control station (FSCS	28	28	28	28
Unit Heater controls	23 09 23	23 09 23	23 09 23	26

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Work/Item/System	Furnish	Install	Low Voltage Wiring	Line Power
(not furnished with equipment)				
AC-20 space-mounted controls (not furnished with equipment)	23 09 23	23 09 23	23 09 23	26
AC-20 unit-mounted controls (not furnished with equipment)	23 09 23	23 09 23	23 09 23	26
Starters, HOA switches	23	23	N/A	26

This facility's existing direct-digital control system is manufactured by Johnson Controls, and its ECC is located at the Chiller Plant (Building 503). The existing system's ECC and top-end controllers were installed in 2011. 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.

F. 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

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technical specifications shall integrate the ASHRAE Standard 135, BACnet/IP control network(s) with the Control System Integrator's area control through an Ethernet connection provided by the Control System Integrator.

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 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 contractor	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		X	
Controller and LAN system verification	X		

- H. Unitary standalone systems including Unit Heaters, Cabinet Unit Heaters, Fan Coil Units, Base Board Heaters, thermal comfort ventilation fans, and similar units for control of room environment

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conditions may be equipped with integral controls furnished and installed by the equipment manufacturer or field mounted. Refer to equipment specifications and as indicated in project documents. Application of standalone unitary controls is limited to at least those systems wherein remote monitoring, alarm and start-up are not necessary. Examples of such systems include:

1. Light-switch-operated toilet exhaust
 2. Vestibule heater
 3. Exterior stair heater
 4. Attic heating and ventilation
 5. Mechanical or electrical room heating and ventilation.
- I. 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 by the VA.

1.2 RELATED WORK

- A. Section 22 15 00, General Service Compressed-Air Systems.
- B. Section 22 33 00, Electric Domestic Water Heaters.
- C. Section 23 21 13, Hydronic Piping.
- D. Section 23 22 13, Steam and Condensate Heating Piping.
- E. Section 23 31 00, HVAC Ducts and Casings.
- F. Section 23 36 00, Air Terminal Units.
- G. Section 23 73 43, Custom, Indoor, Central-Station Air-Handling Units.
- H. Section 23 74 43, Custom, Outdoor, Central-Station Air-Handling Units.
- I. Section 23 81 00, Decentralized Unitary HVAC Equipment.
- J. Section 26 05 11, Requirements for Electrical Installations.
- K. Section 26 05 19, Low-Voltage Electrical Power Conductors and Cables.
- L. Section 26 05 26, Grounding and Bonding for Electrical Systems.
- M. Section 26 05 33, Raceway and Boxes for Electrical Systems.
- N. Section 26 09 23, Lighting Controls.
- O. Section 26 27 26, Wiring Devices.
- P. Section 26 29 11, Motor Controllers.
- Q. Section 28 31 00, Fire Detection and Alarm.

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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. ARCNET: ANSI/ATA 878.1 - Attached Resource Computer Network. ARCNET is a deterministic LAN technology; meaning it's possible to determine the maximum delay before a device is able to transmit a message.
- C. Analog: A continuously varying signal value (e.g., temperature, current, velocity etc.
- D. BACnet: A Data Communication Protocol for Building Automation and Control Networks, ANSI/ASHRAE Standard 135. This communications protocol allows diverse building automation devices to communicate data over and services over a network.
- E. 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.
- F. BACnet Internetwork: Two or more BACnet networks connected with routers. The two networks may sue different LAN technologies.
- G. 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.
- H. BACnet Segment: One or more physical segments of BACnet devices on a BACnet network, connected at the physical layer by repeaters.
- I. 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.
- J. 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.
- K. BACnet Testing Laboratories (BTL). The organization responsible for testing products for compliance with the BACnet standard, operated under the direction of BACnet International.

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- L. 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).
- M. 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.
- N. 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.
- O. Bus Topology: A network topology that physically interconnects workstations and network devices in parallel on a network segment.
- P. 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
- Q. 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).
- R. Device: a control system component that contains a BACnet Device Object and uses BACnet to communicate with other devices.
- S. 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.
- T. Device Profile: A specific group of services describing BACnet capabilities of a device, as defined in ASHRAE Standard 135-2008, Annex L. Standard device profiles include BACnet Operator Workstations (B-OWS), BACnet Building Controllers (B-BC), BACnet Advanced Application Controllers (B-AAC), BACnet Application Specific Controllers (B-ASC), BACnet Smart Actuator (B-SA), and BACnet Smart Sensor (B-SS). Each device used in new construction is required to have a PICS statement listing which service and BIBBs are supported by the device.

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- U. 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.
- V. 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.
- W. 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.
- X. 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.
- Y. DXF: An AutoCAD 2-D graphics file format. Many CAD systems import and export the DXF format for graphics interchange.
- Z. 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.
- AA. 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.
- BB. 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.
- CC. Ethernet: A trademark for a system for exchanging messages between computers on a local area network using coaxial, fiber optic, or twisted-pair cables.

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- DD. Firmware: Firmware is software programmed into read only memory (ROM) chips. Software may not be changed without physically altering the chip.
- EE. 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.
- FF. GIF: Abbreviation of Graphic interchange format.
- GG. 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.
- HH. Graphic Sequence of Operation: It is a graphical representation of the sequence of operation, showing all inputs and output logical blocks.
- II. 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.
- JJ. 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.
- KK. JPEG: A standardized image compression mechanism stands for Joint Photographic Experts Group, the original name of the committee that wrote the standard.
- LL. Local Area Network (LAN): A communication bus that interconnects operator workstation and digital controllers for peer-to-peer communications, sharing resources and exchanging information.
- MM. Network Repeater: A device that receives data packet from one network and rebroadcasts to another network. No routing information is added to the protocol.

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- NN. MS/TP: Master-slave/token-passing (ISO/IEC 8802, Part 3). It is not an acceptable LAN option for VA health-care facilities. It uses twisted-pair wiring for relatively low speed and low cost communication.
- OO. Native BACnet Device: A device that uses BACnet as its primary method of communication with other BACnet devices without intermediary gateways. A system that uses native BACnet devices at all levels is a native BACnet system.
- PP. Network Number: A site-specific number assigned to each network segment to identify for routing. This network number must be unique throughout the BACnet internetwork.
- QQ. Object: The concept of organizing BACnet information into standard components with various associated properties. Examples include analog input objects and binary output objects.
- RR. Object Identifier: An object property used to identify the object, including object type and instance. Object Identifiers must be unique within a device.
- SS. Object Properties: Attributes of an object. Examples include present value and high limit properties of an analog input object. Properties are defined in ASHRAE 135; some are optional and some are required. Objects are controlled by reading from and writing to object properties.
- TT. Operating system (OS): Software, which controls the execution of computer application programs.
- UU. PCX: File type for an image file. When photographs are scanned onto a personal computer they can be saved as PCX files and viewed or changed by a special application program as Photo Shop.
- VV. Peripheral: Different components that make the control system function as one unit. Peripherals include monitor, printer, and I/O unit.
- WW. Peer-to-Peer: A networking architecture that treats all network stations as equal partners- any device can initiate and respond to communication with other devices.

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- XX. PICS: Protocol Implementation Conformance Statement, describing the BACnet capabilities of a device. All BACnet devices have published PICS.
- YY. PID: Proportional, integral, and derivative control, used to control modulating equipment to maintain a setpoint.
- ZZ. Repeater: A network component that connects two or more physical segments at the physical layer.
- AAA. Router: a component that joins together two or more networks using different LAN technologies. Examples include joining a BACnet Ethernet LAN to a BACnet MS/TP LAN.
- BBB. Sensors: devices measuring state points or flows, which are then transmitted back to the DDC system.
- CCC. Thermostats: devices measuring temperatures, which are used in control of standalone or unitary systems and equipment not attached to the DDC system.

1.4 QUALITY ASSURANCE

A. Criteria:

1. Single Source Responsibility of subcontractor: The Contractor shall obtain hardware and software supplied under this Section and delegate the responsibility to a single source controls installation subcontractor. The controls subcontractor shall be responsible for the complete design, installation, 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 would observe the control systems in full operation.

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4. The controls subcontractor shall have 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' experience in design and installation of building automation systems similar in performance to those specified in this Section. Provide evidence of experience by submitting resumes of the project manager, the local branch manager, project engineer, the application engineering staff, and the electronic technicians who would be involved with the supervision, the engineering, and the installation of the control systems. Training and experience of these personnel shall not be less than three years. Failure to disclose this information will be a ground for disqualification of the supplier.
 6. Provide a competent and experienced Project Manager employed by the Controls Contractor. The Project Manager shall be supported as necessary by other Contractor employees in order to provide professional engineering, technical and management service for the work. The Project Manager shall attend scheduled Project Meetings as required and shall be empowered to make technical, scheduling and related decisions on behalf of the Controls Contractor.
- B. Codes and Standards:
1. All work shall conform to the applicable Codes and Standards.
 2. Electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Governing Radio Frequency Electromagnetic Interference, and be so labeled.

1.5 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.

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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:

Space temperature	$\pm 0.5^{\circ}\text{C}$ ($\pm 1^{\circ}\text{F}$)
Ducted air temperature	$\pm 0.5^{\circ}\text{C}$ [$\pm 1^{\circ}\text{F}$]
Outdoor air temperature	$\pm 1.0^{\circ}\text{C}$ [$\pm 2^{\circ}\text{F}$]
Dew Point	$\pm 1.5^{\circ}\text{C}$ [$\pm 3^{\circ}\text{F}$]
Water temperature	$\pm 0.5^{\circ}\text{C}$ [$\pm 1^{\circ}\text{F}$]
Relative humidity	$\pm 2\%$ RH

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Water flow	±1% of reading
Air flow (terminal)	±10% of reading
Air flow (measuring stations)	±5% of reading
Air pressure (ducts)	±25 Pa [±0.1"w.c.]
Air pressure (space)	±0.3 Pa [±0.001"w.c.]
Water pressure	±2% of full scale *Note 1
Electrical Power	±0.5% of reading

Note 1: For both absolute and differential pressure, Control stability and accuracy: Control sequences shall maintain measured variable at setpoint within the following tolerances:

Controlled Variable	Control Accuracy	Range of Medium
Air Pressure	±50 Pa (±0.2 in. w.g.)	0-1.5 kPa (0-6 in. w.g.)
Air Pressure	±3 Pa (±0.01 in. w.g.)	-25 to 25 Pa (-0.1 to 0.1 in. w.g.)
Airflow	±10% of full scale	
Space Temperature	±1.0°C (±2.0°F)	
Duct Temperature	±1.5°C (±3°F)	
Humidity	±5% RH	
Fluid Pressure	±10 kPa (±1.5 psi)	0-1 MPa (1-150 psi)
Fluid Pressure	±250 Pa (±1.0 in. w.g.)	0-12.5 kPa (0-50 in. w.g.) differential

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.

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1.7 SUBMITTALS

- A. Submit shop drawings in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Manufacturer's literature and data for all components including the following:
 - 1. A wiring diagram for each type of input device and output device including DDC controllers, modems, repeaters, etc. Diagram shall show how the device is wired and powered, showing typical connections at the digital controllers and each power supply, as well as the device itself. Show for all field connected devices, including but not limited to, control relays, motor starters, electric or electronic actuators, and temperature pressure, flow and humidity sensors and transmitters.
 - 2. A diagram of each terminal strip, including digital controller terminal strips, terminal strip location, termination numbers and the associated point names.
 - 3. Control dampers and control valves schedule, including the size and pressure drop.
 - 4. 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 HVAC system and the associated control diagrams. Equipment and control labels shall correspond to those shown on the drawings.

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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 and all control panels.
 12. Scaled 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 are the responsibility of the contractor administered by this Section of the technical specifications.
- C. Product Certificates: Compliance with Article, QUALITY ASSURANCE.
- D. Licenses: Provide licenses for all software residing on and used by the Controls Systems and transfer these licenses to the Owner prior to completion.
- E. 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) stick set of applicable control system prints for each mechanical system for wall mounting. The documents shall be submitted for approval prior to final completion.

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3. Furnish one (1) CD-ROM in CAD DWG and/or .DXF format for the drawings noted in subparagraphs above.
- F. 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.
- G. Submit Performance Report to Contracting Officers Representative (COR) prior to final inspection.

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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.
1. First Phase: Formal instructions to the VA facilities personnel for a total of 16 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. Second Phase: This phase of training shall comprise of on the job training during start-up, checkout period, and performance test period. VA facilities personnel will work with the Contractor's installation and test personnel on a daily basis during start-up and checkout period. During the performance test period, controls subcontractor will provide 8 hours of instructions, given in multiple training sessions (each no longer than four hours in length), to the VA facilities personnel.
 3. 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.
 4. 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°C (65 to 90°F) at a relative humidity of 20 to 80% non-condensing.
- B. The CUs used outdoors shall be mounted in NEMA 4 waterproof enclosures, and shall be rated for operation at -40 to 65°C (-40 to 150°F).
- C. All electronic equipment shall operate properly with power fluctuations of plus 10 percent to minus 15 percent of nominal supply voltage.

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- D. Sensors and controlling devices shall be designed to operate in the environment, which they are sensing or controlling.

1.10 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):
Standard 135-10.....BACNET Building Automation and Control Networks
- C. American Society of Mechanical Engineers (ASME):
B16.18-01.....Cast Copper Alloy Solder Joint Pressure Fittings.
B16.22-01.....Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
- D. American Society of Testing Materials (ASTM):
B32-08.....Standard Specification for Solder Metal
B88-09.....Standard Specifications for Seamless Copper Water Tube
B88M-09.....Standard Specification for Seamless Copper Water Tube (Metric)
B280-08.....Standard Specification for Seamless Copper Tube for Air-Conditioning and Refrigeration Field Service
D2737-03.....Standard Specification for Polyethylene (PE) Plastic Tubing
- E. Federal Communication Commission (FCC):
Rules and Regulations Title 47 Chapter 1-2001 Part 15: Radio Frequency Devices.
- F. Institute of Electrical and Electronic Engineers (IEEE):
802.3-11.....Information Technology-Telecommunications and Information Exchange between Systems-Local and Metropolitan Area Networks- Specific Requirements-Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access method and Physical Layer Specifications
- G. National Fire Protection Association (NFPA):
70-14.....National Electric Code
90A-15.....Standard for Installation of Air-Conditioning and Ventilation Systems
- H. Underwriter Laboratories Inc (UL):

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PART 2 - PRODUCTS

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.

A. General

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- 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 start-up at their cost and shall cooperate fully with the contractor administered by this Section of the technical specifications in a timely manner and at their cost to ensure complete functional integration.

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 135-2008, BACnet.

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1. The Data link / physical layer protocol (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 not acceptable 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. Internetwork operator interface and value passing shall be transparent to internetwork architecture.
1. An operator interface connected to a controller shall allow the operator to interface with each internetwork controller as if directly connected. Controller information such as data, status, reports, system software, and custom programs shall be viewable and editable from each internetwork controller.
 2. Inputs, outputs, and control variables used to integrate control strategies across multiple controllers shall be readable by each controller on the internetwork. Program and test all cross-controller links required to execute specified control system operation. An authorized operator shall be able to edit cross-controller links by typing a standard object address.
- D. 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.
- E. 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

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"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 #" = "FFFNDD" 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 above 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

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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 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 of the Devices through links in the BTL website.
1. BACnet Building Controllers, historically referred to as NACs, 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.

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2.6 CONTROLLERS

- A. General. Provide an adequate number of BTL-Listed B-BC building controllers and an adequate number of BTL-Listed B-AAC advanced application controllers to achieve the performance specified in the Part 1 Article on "System Performance." Each of these controllers shall meet the following requirements.
1. The controller shall have sufficient memory to support its operating system, database, and programming requirements.
 2. The building controller shall share data with the ECC and the other networked building controllers. The advanced application controller shall share data with its building controller and the other networked advanced application controllers.
 3. The operating system of the controller shall manage the input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
 4. Controllers that perform scheduling shall have a real-time clock.
 5. The controller shall continually check the status of its processor and memory circuits. If an abnormal operation is detected, the controller shall:
 - a. assume a predetermined failure mode, and
 - b. generate an alarm notification.
 6. The controller shall communicate with other BACnet devices on the internetwork using the BACnet Read (Execute and Initiate) and Write (Execute and Initiate) Property services.
 7. 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. The controller shall provide a service communication port using BACnet Data Link/Physical layer protocol for connection to a portable operator's terminal.

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8. 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 shall be available to prevent unauthorized use of the keypad and display.
 9. 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.
 10. Memory. The controller shall maintain all BIOS and programming information in the event of a power loss for at least 72 hours.
 11. The controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. Controller operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft.).
- 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.

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4. Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
5. Memory. The application specific controller shall use nonvolatile memory and maintain all BIOS and programming information in the event of a power loss.
6. Immunity to power and noise. Controllers shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80%. Operation shall be protected against electrical noise of 5-120 Hz and from keyed radios up to 5 W at 1 m (3 ft).
7. Transformer. Power supply for the ASC must be rated at a minimum of 125% of ASC power consumption and shall be of the fused or current limiting type.

C. Direct Digital Controller Software

1. The software programs specified in this section shall be commercially available, concurrent, multi-tasking operating system and support the use of software application that operates under DOS or Microsoft Windows.
2. All points shall be identified by up to 30-character point name and 16-character point descriptor. The same names shall be used at the ECC.
3. All control functions shall execute within the stand-alone control units via DDC algorithms. 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.
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

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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 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. Power Demand Limiting (PDL): Power demand limiting program shall monitor the building power consumption and limit the consumption of electricity to prevent peak demand charges. PDL shall continuously track the electricity consumption from a pulse input generated at the kilowatt-hour/demand electric meter. PDL shall sample the meter data to continuously forecast the electric demand likely to be used during successive time intervals. If the forecast demand indicates that electricity usage will likely to exceed a user preset maximum allowable level, then PDL shall automatically shed

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electrical loads. Once the demand load has met, loads that have been shed shall be restored and returned to normal mode. Control system shall be capable of demand limiting by resetting the HVAC system set points to reduce load while maintaining indoor air quality.

- b. Economizer: An economizer program shall be provided for VAV systems. This program shall control the position of air handler relief, return, and outdoors dampers. If the outdoor air dry bulb temperature and humidity fall below changeover set point the energy control center will modulate the dampers to provide 100 percent outdoor air. The operator shall be able to override the economizer cycle and return to minimum outdoor air operation at any time.
- c. Night Setback/Morning Warm up Control: The system shall provide the ability to automatically adjust set points for this mode of operation.
- d. Optimum Start/Stop (OSS): Optimum start/stop program shall automatically be coordinated with event scheduling. The OSS program shall start HVAC equipment at the latest possible time that will allow the equipment to achieve the desired zone condition by the time of occupancy, and it shall also shut down HVAC equipment at the earliest possible time before the end of the occupancy period and still maintain desired comfort conditions. The OSS program shall consider both outside weather conditions and inside zone conditions. The program shall automatically assign longer lead times for weekend and holiday shutdowns. The program shall poll all zones served by the associated AHU and shall select the warmest and coolest zones. These shall be used in the start time calculation. It shall be possible to assign occupancy start times on a per air handler unit basis. The program shall meet the local code requirements for minimum outdoor air while the building is occupied. Modification of assigned occupancy start/stop times shall be possible via the ECC.

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- e. Event Scheduling: Provide a comprehensive menu driven program to automatically start and stop designated points or a group of points according to a stored time. This program shall provide the capability to individually command a point or group of points. When points are assigned to one common load group it shall be possible to assign variable time advances/delays between each successive start or stop within that group. Scheduling shall be calendar based and advance schedules may be defined up to one year in advance. Advance schedule shall override the day-to-day schedule. The operator shall be able to define the following information:
 - 1) Time, day.
 - 2) Commands such as on, off, auto.
 - 3) Time delays between successive commands.
 - 4) Manual overriding of each schedule.
 - 5) Allow operator intervention.
- f. 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.
- g. Remote Communications: The system shall have the ability to dial out in the event of an alarm to the ECC and alpha-numeric pagers. The alarm message shall include the name of the calling location, the device that generated the alarm, and the alarm message itself. The operator shall be able to remotely access and operate the system using dial up communications. Remote access shall allow the operator to function the same as local access.
- h. Maintenance Management (PM): The program shall monitor equipment status and generate maintenance messages based upon the operators defined equipment run time, starts, and/or

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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 STEAM)

- A. Sensors' measurements shall be read back to the DDC system, and shall be visible by the ECC.
- B. Temperature and Humidity Sensors shall be electronic, vibration and corrosion resistant for wall, immersion, and/or duct mounting. Provide all remote sensors as required for the systems.
 - 1. Temperature Sensors: thermistor type for terminal units and Resistance Temperature Device (RTD) with an integral transmitter type for all other sensors.
 - a. Duct sensors shall be rigid or averaging type as shown on drawings. Averaging sensor shall be a minimum of 1 linear ft of sensing element for each sq ft of cooling coil face area.
 - b. Immersion sensors shall be provided with a separable well made of stainless steel, bronze or monel material. Pressure rating of well is to be consistent with the system pressure in which it is to be installed.
 - c. Space sensors shall be equipped with in-space User set-point adjustment, override switch, numerical temperature display on sensor cover, and communication port. Match room thermostats. Provide a tooled-access cover.
 - 1) Public space sensor: setpoint adjustment shall be only through the ECC or through the DDC system's diagnostic device/laptop. Do not provide in-space User set-point adjustment. Provide an opaque keyed-entry cover if needed to restrict in-space User set-point adjustment.
 - 2) Psychiatric patient room sensor: sensor shall be flush with wall, shall not include an override switch, numerical temperature display on sensor cover, shall not include a

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- communication port and shall not allow in-space User set-point adjustment. Setpoint adjustment shall be only through the ECC or through the DDC system's diagnostic device/laptop. Provide a stainless steel cover plate with an insulated back and security screws.
- d. Outdoor air temperature sensors shall have watertight inlet fittings and be shielded from direct sunlight.
 - e. Room security sensors shall have stainless steel cover plate with insulated back and security screws.
 - f. Wire: Twisted, shielded-pair cable.
 - g. Output Signal: 4-20 ma.
2. Humidity Sensors: Bulk polymer sensing element type.
- a. Duct and 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. Outdoor humidity sensors shall be furnished with element guard and mounting plate and have a sensing range of 0 to 100 percent RH.
 - c. 4-20 ma continuous output signal.
- C. Static Pressure Sensors: Non-directional, temperature compensated.
- 1. 4-20 ma output signal.
 - 2. 0 to 5 inches wg for duct static pressure range.
 - 3. 0 to 0.25 inch wg for Building static pressure range.
- D. Water flow sensors:
- 1. Type: Insertion vortex type with retractable probe assembly and 2 inch full port gate valve.
 - a. Pipe size: 3 to 24 inches.
 - b. Retractor: ASME threaded, non-rising stem type with hand wheel.
 - c. Mounting connection: 2 inch 150 PSI flange.
 - d. Sensor assembly: Design for expected water flow and pipe size.
 - e. Seal: Teflon (PTFE).
 - 2. Controller:
 - a. Integral to unit.

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- b. Locally display flow rate and total.
 - c. Output flow signal to BMCS: Digital pulse type.
- 3. Performance:
 - a. Turndown: 20:1
 - b. Response time: Adjustable from 1 to 100 seconds.
 - c. Power: 24 volt DC
- 4. Install flow meters according to manufacturer's recommendations.
Where recommended by manufacturer because of mounting conditions,
provide flow rectifier.
- E. Flow switches:
 - 1. Shall be either paddle or differential pressure type.
 - a. Paddle-type switches (liquid service only) shall be UL Listed, SPDT snap-acting, adjustable sensitivity with NEMA 4 enclosure.
 - b. Differential pressure type switches (air or water service) shall be UL listed, SPDT snap acting, NEMA 4 enclosure, with scale range and differential suitable for specified application.
- F. 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.

2.8 CONTROL CABLES

- A. General:
 - 1. Ground cable shields, drain conductors, and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments. Comply with 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

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electronic private branch exchange (EPBX) equipment the System may service.

4. The as-installed drawings shall identify each cable as labeled, used cable, and bad cable pairs.
5. Label system's cables on each end. Test and certify cables in writing to the VA before conducting proof-of-performance testing. Minimum cable test requirements are for impedance compliance, inductance, capacitance, signal level compliance, opens, shorts, cross talk, noise, and distortion, and split pairs on all cables in the frequency ranges used. Make available all cable installation and test records at demonstration to the VA. All changes (used pair, failed pair, etc.) shall be posted in these records as the change occurs.
6. Power wiring shall not be run in conduit with communications trunk wiring or signal or control wiring operating at 100 volts or less.
- B. Analog control cabling shall be not less than No. 18 AWG solid, with thermoplastic insulated conductors as specified in Section 26 05 21.
- C. Copper digital communication cable between the ECC and the B-BC and B-AAC controllers shall be 100BASE-TX Ethernet, Category 5e or 6, not less than minimum 24 American Wire Gauge (AWG) solid, Shielded Twisted Pair (STP) or Unshielded Twisted Pair (UTP), with thermoplastic insulated conductors, enclosed in a thermoplastic outer jacket, as specified in Section 27 15 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.
- D. Optical digital communication fiber, if used, shall be Multimode or Singlemode fiber, 62.5/125 micron for multimode or 10/125 micron for singlemode 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.

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2.8 THERMOSTATS AND HUMIDISTATS

- A. Room thermostats controlling unitary standalone heating and cooling devices not connected to the DDC system shall have three modes of operation (heating - null or dead band - cooling). Wall mounted thermostats shall have standard finish, setpoint range and temperature display and external adjustment:
 - 1. Electronic Thermostats: Solid-state, microprocessor based, programmable to daily, weekend, and holiday schedules.
 - a. Public Space Thermostat: Public space thermostat shall have a thermistor sensor and shall not have a visible means of set point adjustment. Adjustment shall be via the digital controller to which it is connected.
 - b. Battery replacement without program loss.
- B. Strap-on thermostats shall be enclosed in a dirt-and-moisture proof housing with fixed temperature switching point and single pole, double throw switch.
- C. Freezestats shall have a minimum of 300 mm (one linear foot) of sensing element for each 0.093 square meter (one square foot) of coil area. A freezing condition at any increment of 300 mm (one foot) anywhere along the sensing element shall be sufficient to operate the thermostatic element. Freezestats shall be manually-reset.
- D. Room Humidistats: Provide fully proportioning humidistat with adjustable throttling range for accuracy of settings and conservation. The humidistat shall have set point scales shown in percent of relative humidity located on the instrument. Systems showing moist/dry or high/low are not acceptable.

2.9 FINAL CONTROL ELEMENTS AND OPERATORS

- A. Fail Safe Operation: Control valves and dampers shall provide "fail safe" operation in either the normally open or normally closed position as required for freeze, moisture, and smoke or fire protection.
- B. Spring Ranges: Range as required for system sequencing and to provide tight shut-off.
- C. Power Operated Control Dampers (other than VAV Boxes): Factory fabricated, balanced type dampers. All modulating dampers shall be opposed blade type and gasketed. Blades for two-position, duct-mounted

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dampers shall be parallel, airfoil (streamlined) type for minimum noise generation and pressure drop.

1. Leakage: Except as specified in subparagraph 2 below, maximum leakage in closed position shall not exceed 7 L/S (15 CFMs) differential pressure for outside air and exhaust dampers and 200 L/S/ square meter (40 CFM/sq. ft.) at 50 mm (2 inches) differential pressure for other dampers.
 2. Frame shall be galvanized steel channel with seals as required to meet leakage criteria.
 3. Blades shall be galvanized steel or aluminum, 200 mm (8 inch) maximum width, with edges sealed as required.
 4. Bearing shall be nylon, bronze sleeve or ball type.
 5. Hardware shall be zinc-plated steel. Connected rods and linkage shall be non-slip. Working parts of joints shall be brass, bronze, nylon or stainless steel.
 6. Maximum air velocity and pressure drop through free area the dampers:
 - a. Smoke damper in air handling unit: 305 meter per minute (1000 fpm).
 - b. Duct mounted damper: 600 meter per minute (2000 fpm).
 - c. Maximum static pressure loss: 50 Pascal (0.20 inches water gage).
- D. Smoke Dampers and Combination Fire/Smoke Dampers: Dampers and operators are specified in Section 23 31 00, HVAC DUCTS AND CASINGS. Control of these dampers is specified under this Section.
- E. Control Valves:
1. Valves shall be rated for a minimum of 150 percent of system operating pressure at the valve location but not less than 900 kPa (125 psig).
 2. Valves 50 mm (2 inches) and smaller shall be bronze body with threaded or flare connections.
 3. Valves 60 mm (2 1/2 inches) and larger shall be bronze or iron body with flanged connections.
 4. Brass or bronze seats except for valves controlling media above 100 degrees C (210 degrees F), which shall have stainless steel seats.

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5. Flow characteristics:

- a. Three way modulating valves shall be globe pattern. Position versus flow relation shall be linear relation for steam or equal percentage for water flow control.
- b. Two-way modulating valves shall be globe pattern. Position versus flow relation shall be linear for steam and equal percentage for water flow control.
- c. Two-way 2-position valves shall be ball, gate or butterfly type.

6. Maximum pressure drop:

- a. Two position steam control: 20 percent of inlet gauge pressure.
- b. Modulating Steam Control: 80 percent of inlet gauge pressure (acoustic velocity limitation).
- c. Modulating water flow control, greater of 3 meters (10 feet) of water or the pressure drop through the apparatus.

7. Two position water valves shall be line size.

F. Damper and Valve Operators and Relays:

1. Electric operator shall provide full modulating control of dampers and valves. A linkage and pushrod shall be furnished for mounting the actuator on the damper frame internally in the duct or externally in the duct or externally on the duct wall, or shall be furnished with a direct-coupled design. Metal parts shall be aluminum, mill finish galvanized steel, or zinc plated steel or stainless steel. Provide actuator heads which allow for electrical conduit attachment. The motors shall have sufficient closure torque to allow for complete closure of valve or damper under pressure. Provide multiple motors as required to achieve sufficient close-off torque.
 - a. Minimum valve close-off pressure shall be equal to the system pump's dead-head pressure, minimum 50 psig for valves smaller than 4 inches.
2. Electronic damper operators: Metal parts shall be aluminum, mill finish galvanized steel, or zinc plated steel or stainless steel. Provide actuator heads which allow for electrical conduit

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attachment. The motors shall have sufficient closure torque to allow for complete closure of valve or damper under pressure. Provide multiple motors as required to achieve sufficient close-off torque.

- a. VAV Box actuator shall be mounted on the damper axle or shall be of the air valve design, and shall provide complete modulating control of the damper. The motor shall have a closure torque of 35-inch pounds minimum with full torque applied at close off to attain minimum leakage.

3. See drawings for required control operation.

2.10 AIR FLOW CONTROL

- A. Airflow and static pressure shall be controlled via digital controllers with inputs from airflow control measuring stations and static pressure inputs as specified. Controller outputs shall be analog or pulse width modulating output signals. The controllers shall include the capability to control via simple proportional (P) control, proportional plus integral (PI), proportional plus integral plus derivative (PID), and on-off. The airflow control programs shall be factory-tested programs that are documented in the literature of the control manufacturer.

- B. Air Flow Measuring Station -- Electronic Thermal Type:

1. Air Flow Sensor Probe:

- a. Each air flow sensor shall contain two individual thermal sensing elements. One element shall determine the velocity of the air stream while the other element shall compensate for changes in temperature. Each thermal flow sensor and its associated control circuit and signal conditioning circuit shall be factory calibrated and be interchangeable to allow replacement of a sensor without recalibration of the entire flow station. The sensor in the array shall be located at the center of equal area segment of the duct and the number of sensors shall be adequate to accommodate the expected velocity profile and variation in flow and temperature. The airflow station shall be of the insertion type in which sensor support structures are inserted from the outside of the ducts to make up the complete electronic velocity array.

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- b. Thermal flow sensor shall be constructed of hermetically sealed thermistors or nickel chromium or reference grade platinum wire, wound over an epoxy, stainless steel or ceramic mandrel and coated with a material suitable for the conditions to be encountered. Each dual sensor shall be mounted in an extruded aluminum alloy strut.
2. Air Flow Sensor Grid Array:
- a. Each sensor grid shall consist of a lattice network of temperature sensors and linear integral controllers (ICs) situated inside an aluminum casing suitable for mounting in a duct. Each sensor shall be mounted within a strut facing downstream of the airflow and located so that it is protected on the upstream side. All wiring shall be encased (out of the air stream) to protect against mechanical damage.
 - b. The casing shall be made of welded aluminum of sufficient strength to prevent structural bending and bowing. Steel or iron composite shall not be acceptable in the casing material.
 - c. Pressure drop through the flow station shall not exceed 4 Pascal (0.015" W.G.) at 1,000 meter per minute (3,000 FPM).
3. Electronics Panel:
- a. Electronics Panel shall consist of a surface mounted enclosure complete with solid-state microprocessor and software.
 - b. Electronics Panel shall be A/C powered 24 VAC and shall have the capability to transmit signals of 0-5 VDC, 0-10 VCD or 4-20 ma for use in control of the HVAC Systems. The electronic panel shall have the capability to accept user defined scaling parameters for all output signals.
 - c. Electronics Panel shall have the capability to digitally display airflow in CFM and temperature in degrees F. The displays shall be provided as an integral part of the electronics panel. The electronic panel shall have the capability to totalize the output flow in CFM for two or more systems, as required. A single output signal may be provided which will equal the sum of the systems totalized. Output signals shall be provided for temperature and airflow. Provide

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remote mounted air flow or temperature displays where indicated on the plans.

d. Electronics Panel shall have the following:

- 1) Minimum of 12-bit A/D conversion.
- 2) Field adjustable digital primary output offset and gain.
- 3) Airflow analog output scaling of 100 to 10,000 FPM.
- 4) Temperature analog output scaling from -45°C to 70°C (-50°F to 160°F).
- 5) Analog output resolution (full scale output) of 0.025%.

e. All readings shall be in I.P. units.

4. Thermal flow sensors and its electronics shall be installed as per manufacturer's instructions. The probe sensor density shall be as follows:

Probe Sensor Density	
Area (sq.ft.)	Qty. Sensors
<=1	2
>1 to <4	4
4 to <8	6
8 to <12	8
12 to <16	12
>=16	16

- a. Complete installation shall not exhibit more than $\pm 2.0\%$ error in airflow measurement output for variations in the angle of flow of up to 10 percent in any direction from its calibrated orientation. Repeatability of readings shall be within $\pm 0.25\%$.

- C. Static Pressure Measuring Station: shall consist of one or more static pressure sensors and transmitters along with relays or auxiliary devices as required for a complete functional system. The span of the transmitter shall not exceed two times the design static pressure at the point of measurement. The output of the transmitter shall be true representation of the input pressure with plus or minus 25 Pascal (0.1 inch) W.G. of the true input pressure:

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1. Static pressure sensors shall have the same requirements as Airflow Measuring Devices except that total pressure sensors are optional, and only multiple static pressure sensors positioned on an equal area basis connected to a network of headers are required.
2. For systems with multiple major trunk supply ducts, furnish a static pressure transmitter for each trunk duct. The transmitter signal representing the lowest static pressure shall be selected and this shall be the input signal to the controller.
3. The controller shall receive the static pressure transmitter signal and CU shall provide a control output signal to the supply fan capacity control device. The control mode shall be proportional plus integral (PI) (automatic reset) and where required shall also include derivative mode.
4. In systems with multiple static pressure transmitters, provide a switch located near the fan discharge to prevent excessive pressure during abnormal operating conditions. High-limit switches shall be manually-reset.
5. Systems shall consist of an air flow measuring station for each supply and return duct, the CU and such relays, as required to provide a complete functional system that will maintain a constant flow rate difference between supply and return air to an accuracy of $\pm 10\%$. In systems where there is no suitable location for a flow measuring station that will sense total supply or return flow, provide multiple flow stations with a differential pressure transmitter for each station. Signals from the multiple transmitters shall be added through the CU such that the resultant signal is a true representation of total flow.
6. The total flow signals from supply and return air shall be the input signals to the CU. This CU shall track the return air fan capacity in proportion to the supply air flow under all conditions.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General:

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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 plum.

B. Electrical Wiring Installation:

1. All wiring 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 Section 26 05 21. Install digital communication cables in conduit and in accordance with Specification Section 27 15 00, Communications Horizontal Cabling.
3. Install conduit and wiring between operator workstation(s), digital controllers, electrical panels, indicating devices, instrumentation, miscellaneous alarm points, thermostats, and relays as shown on the drawings or as required under this section.
4. Install all electrical work required for a fully functional system and not shown on electrical plans or required by electrical

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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.

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- 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.
 - e. Mount sensors rigidly and adequately for the environment within which the sensor operates. Separate extended-bulb sensors from contact with metal casings and coils using insulated standoffs.
 - f. Sensors used in mixing plenum, and hot and cold decks shall be of the averaging of type. Averaging sensors shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip.
 - g. All pipe mounted temperature sensors shall be installed in wells.
 - h. All wires attached to sensors shall be air sealed in their conduits or in the wall to stop air transmitted from other areas affecting sensor reading.
 - i. Permanently mark terminal blocks for identification. Protect all circuits to avoid interruption of service due to short-circuiting or other conditions. Line-protect all wiring that comes from external sources to the site from lightning and static electricity.
2. Pressure Sensors:
- a. Install duct static pressure sensor tips facing directly downstream of airflow.
 - b. Install high-pressure side of the differential switch between the pump discharge and the check valve.
 - c. Install snubbers and isolation valves on steam pressure sensing devices.
3. Actuators:
- a. Mount and link damper and valve actuators according to manufacturer's written instructions.

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- b. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed position.
 - c. Check operation of valve/actuator combination to confirm that actuator modulates valve smoothly in both open and closed position.
 - 4. Flow Switches:
 - a. Install flow switch according to manufacturer's written instructions.
 - b. Mount flow switch a minimum of 5 pipe diameters up stream and 5 pipe diameters downstream or 600 mm (2 feet) whichever is greater, from fittings and other obstructions.
 - c. Assure correct flow direction and alignment.
 - d. Mount in horizontal piping-flow switch on top of the pipe.
- D. Installation of network:
 - 1. Ethernet:
 - a. The network shall employ Ethernet LAN architecture, as defined by IEEE 802.3. The Network Interface shall be fully Internet Protocol (IP) compliant allowing connection to currently installed IEEE 802.3, Compliant Ethernet Networks.
 - b. The network shall directly support connectivity to a variety of cabling types. As a minimum provide the following connectivity: 100 Base TX (Category 5e cabling) for the communications between the ECC and the B-BC and the B-AAC controllers.
 - 2. Third party interfaces: Contractor shall integrate real-time data from building systems by other trades and databases originating from other manufacturers as specified and required to make the system work as one system.
- E. Installation of digital controllers and programming:
 - 1. Provide a separate digital control panel for each major piece of equipment, such as air handling unit, 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.

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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 modular in design, 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.
- B. Validation
 1. Prepare and submit for approval a validation test plan including test procedures for the performance verification tests. Test Plan shall 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 insure that system performs in accordance with approved

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specifications and sequences of operation submitted. Installer shall complete and submit Test Check List.

C. Demonstration

1. Following the completion of all tests and calibration, the installer shall perform point-to-point demonstration of the proper operation of all control points in the installed system in the presence of the COR and Chiller Plant Supervisor. Provide the COR with a minimum one (1) weeks' notice of demonstration prior to commencement.
2. Demonstrate to authorities that all required safeties and life safety functions are fully functional and complete.
3. Make accessible, personnel to provide necessary adjustments and corrections to systems as directed by balancing agency.
4. 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.

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- 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 (1) minute. Control loop trend data shall be instantaneous and the time between data points shall not be greater than one (1) minute.
- 5. Witnessed demonstration of ECC functions shall consist of:
 - a. Running each specified report.
 - b. Display and demonstrate each data entry to show site specific customizing capability. Demonstrate parameter changes.
 - c. Step through penetration tree, display all graphics, demonstrate dynamic update, and direct access to graphics.
 - d. Execute digital and analog commands in graphic mode.
 - e. Demonstrate DDC loop precision and stability via trend logs of inputs and outputs (6 loops minimum).
 - f. Demonstrate EMS performance via trend logs and command trace.
 - g. Demonstrate scan, update, and alarm responsiveness.
 - h. Demonstrate spreadsheet/curve plot software, and its integration with database.
 - i. Demonstrate on-line user guide, and help function and mail facility.
 - j. Demonstrate digital system configuration graphics with interactive upline and downline load, and demonstrate specified diagnostics.
 - k. Demonstrate multitasking by showing dynamic curve plot, and graphic construction operating simultaneously via split screen.
 - l. Demonstrate class programming with point options of beep duration, beep rate, alarm archiving, and color banding.

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SECTION 23 21 13
HYDRONIC PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Water piping to connect HVAC equipment, including the following:
 - 1. Chilled water, heating hot water and drain piping.
 - 2. Extension of domestic water make-up piping.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC: General mechanical requirements and items, which are common to more than one section of Division 23.
- D. Section 23 21 23, HYDRONIC PUMPS: Pumps.
- E. Section 23 07 11, HVAC, PLUMBING, and BOILER PLANT INSULATION: Piping insulation.
- F. Section 23 23 00, REFRIGERANT PIPING: Refrigerant piping and refrigerants.
- G. Section 23 25 00, HVAC WATER TREATMENT: Water treatment for open and closed systems.
- H. Section 23 82 00, CONVECTION HEATING AND COOLING UNITS: Dual duct VAV and CV units, fan coil units.
- I. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC: Temperature and pressure sensors and valve operators.

1.3 QUALITY ASSURANCE

- A. Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION, which includes welding qualifications.
- B. Submit prior to welding of steel piping a certificate of Welder's certification. The certificate shall be current and not more than one year old.
- C. All castings used for coupling housings, fittings, valve bodies, etc., shall be date stamped for quality assurance and traceability.

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1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Manufacturer's Literature and Data:
- C. Pipe and equipment supports.
 - 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. Valves of all types.
 - 5. Strainers.
 - 6. Flexible connectors for water service.
 - 7. Pipe alignment guides.
 - 8. Expansion joints.
 - 9. Expansion compensators.
 - 10. All specified hydronic system components.
 - 11. Water flow measuring devices.
 - 12. Gages.
 - 13. Thermometers and test wells.
 - 14. Electric heat tracing systems.
- D. Manufacturer's certified data report, Form No. U-1, for ASME pressure vessels:
 - 1. Air separators.
 - 2. Expansion tanks.
- B. Submit the welder's qualifications in the form of a current (less than one year old) and formal certificate.
- C. Coordination Drawings: Refer to Article, SUBMITTALS of Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- D. As-Built Piping Diagrams: Provide drawing as follows for chilled water and heating hot water system and other piping systems and equipment.
 - 1. One wall-mounted stick file with complete set of prints. Mount stick file in the chiller plant or control room along with control diagram stick file.
 - 2. One complete set of reproducible drawings.
 - 3. One complete set of drawings in electronic Autocad and pdf format.

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1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. American National Standards Institute, Inc.
- B. American Society of Mechanical Engineers/American National Standards Institute, Inc. (ASME/ANSI).
- C. American National Standards Institute, Inc./Fluid Controls Institute (ANSI/FCI):
- 70-2-2006.....Control Valve Seat Leakage
- D. American Society of Mechanical Engineers (ASME):
- B16.1-98.....Cast Iron Pipe Flanges and Flanged Fittings
- B16.3-2006.....Malleable Iron Threaded Fittings: Class 150 and 300
- B16.4-2006.....Gray Iron Threaded Fittings: (Class 125 and 250)
- B16.5-2003.....Pipe Flanges and Flanged Fittings: NPS ½ through NPS 24 Metric/Inch Standard
- B16.9-07.....Factory Made Wrought Butt Welding Fittings
- B16.11-05.....Forged Fittings, Socket Welding and Threaded
- B16.18-01.....Cast Copper Alloy Solder Joint Pressure Fittings
- B16.22-01.....Wrought Copper and Bronze Solder Joint Pressure Fittings.
- B16.24-06.....Cast Copper Alloy Pipe Flanges and Flanged Fittings
- B16.39-06.....Malleable Iron Threaded Pipe Unions
- B16.42-06.....Ductile Iron Pipe Flanges and Flanged Fittings
- B31.1-08.....Power Piping
- E. American Society for Testing and Materials (ASTM):
- A47/A47M-99 (2004).....Ferritic Malleable Iron Castings
- A53/A53M-07.....Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
- A106/A106M-08.....Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service

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A126-04.....Standard Specification for Gray Iron Castings
for Valves, Flanges, and Pipe Fittings
A183-03 Standard Specification for Carbon Steel Track
Bolts and Nuts
A216/A216M-08 Standard Specification for Steel Castings,
Carbon, Suitable for Fusion Welding, for High
Temperature Service
A234/A234M-07 Piping Fittings of Wrought Carbon Steel and
Alloy Steel for Moderate and High Temperature
Service
A307-07 Standard Specification for Carbon Steel Bolts
and Studs, 60,000 PSI Tensile Strength
A536-84 (2004) Standard Specification for Ductile Iron Castings
A615/A615M-08 Deformed and Plain Carbon Steel Bars for
Concrete Reinforcement
A653/A 653M-08 Steel Sheet, Zinc-Coated (Galvanized) or Zinc-
Iron Alloy Coated (Galvannealed) By the Hot-Dip
Process
B32-08 Standard Specification for Solder Metal
B62-02 Standard Specification for Composition Bronze or
Ounce Metal Castings
B88-03 Standard Specification for Seamless Copper Water
Tube
B209-07 Aluminum and Aluminum Alloy Sheet and Plate
C177-04 Standard Test Method for Steady State Heat Flux
Measurements and Thermal Transmission Properties
by Means of the Guarded Hot Plate Apparatus
C478-09 Precast Reinforced Concrete Manhole Sections
C533-07 Calcium Silicate Block and Pipe Thermal
Insulation
C552-07 Cellular Glass Thermal Insulation
D3350-08 Polyethylene Plastics Pipe and Fittings
Materials
C591-08 Unfaced Preformed Rigid Cellular
Polyisocyanurate Thermal Insulation

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- D1784-08 Rigid Poly (Vinyl Chloride) (PVC) Compounds and
Chlorinated Poly (Vinyl Chloride) (CPVC)
Compound
- D1785-06 Poly (Vinyl Chloride) (PVC) Plastic Pipe,
Schedules 40, 80 and 120
- D2241-05 Poly (Vinyl Chloride) (PVC) Pressure Rated Pipe
(SDR Series)
- F439-06 Standard Specification for Chlorinated Poly
(Vinyl Chloride) (CPVC) Plastic Pipe Fittings,
Schedule 80
- F441/F441M-02 Standard Specification for Chlorinated Poly
(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules
40 and 80
- F477-08 Elastomeric Seals Gaskets) for Joining Plastic
Pipe
- F. American Water Works Association (AWWA):
- C110-08.....Ductile Iron and Grey Iron Fittings for Water
- C203-02.....Coal Tar Protective Coatings and Linings for
Steel Water Pipe Lines Enamel and Tape Hot
Applied
- G. American Welding Society (AWS):
- B2.1-02.....Standard Welding Procedure Specification
- H. Copper Development Association, Inc. (CDA):
- CDA A4015-06.....Copper Tube Handbook
- I. Expansion Joint Manufacturer's Association, Inc. (EJMA):
- EMJA-2003.....Expansion Joint Manufacturer's Association
Standards, Ninth Edition
- J. Manufacturers Standardization Society (MSS) of the Valve and Fitting
Industry, Inc.:
- SP-67-02a.....Butterfly Valves
- SP-70-06.....Gray Iron Gate Valves, Flanged and Threaded
Ends
- SP-71-05.....Gray Iron Swing Check Valves, Flanged and
Threaded Ends
- SP-80-08.....Bronze Gate, Globe, Angle and Check Valves

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SP-85-02.....Cast Iron Globe and Angle Valves, Flanged and
Threaded Ends

SP-110-96.....Ball Valves Threaded, Socket-Welding, Solder
Joint, Grooved and Flared Ends

SP-125-00.....Gray Iron and Ductile Iron In-line, Spring
Loaded, Center-Guided Check Valves

K. National Sanitation Foundation/American National Standards Institute,
Inc. (NSF/ANSI):

14-06.....Plastic Piping System Components and Related
Materials

50-2009a.....Equipment for Swimming Pools, Spas, Hot Tubs
and other Recreational Water Facilities -
Evaluation criteria for materials, components,
products, equipment and systems for use at
recreational water facilities

61-2008.....Drinking Water System Components - Health
Effects

L. Tubular Exchanger Manufacturers Association: TEMA 9th Edition, 2007

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 Grade B, seamless or ERW, Schedule 40.

B. Extension of Domestic Water Make-up Piping: ASTM B88, Type K, hard
drawn copper tubing.

C. Cooling Coil Condensate Drain Piping:

1. From air handling units: Copper water tube, ASTM B88, Type M.

2. From fan coil or other terminal units: Copper water tube, ASTM B88,
Type L for runouts and Type M for mains.

D. Pipe supports, including insulation shields, for above ground 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.

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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 not acceptable.
 4. Unions: ASME B16.39.
 5. Water hose connection adapter: Brass, pipe thread to 20 mm (3/4 inch) garden hose thread, with hose cap nut.
- B. 65 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 6 mm (1/8 inch) thick full face neoprene gasket suitable for 104 degrees C (220 degrees F).
 - 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 may be used for branch connections up to one pipe size smaller than the main. Forged steel half-couplings, ASME B16.11 may be used for drain, vent and gage connections.

2.4 FITTINGS FOR COPPER TUBING

- A. Joints:
1. Solder Joints: Joints shall be made up in accordance with recommended practices of the materials applied. Apply 95/5 tin and antimony on all copper piping.
 2. Mechanically formed tee connection in water and drain piping: Form mechanically extracted collars in a continuous operation by drilling pilot hole and drawing out tube surface to form collar, having a height of not less than three times the thickness of tube wall. Adjustable collaring device shall insure proper tolerance and complete uniformity of the joint. Notch and dimple joining branch

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tube in a single process to provide free flow where the branch tube penetrates the fitting.

- B. Bronze Flanges and Flanged Fittings: ASME B16.24.
- C. Fittings: ANSI/ASME B16.18 cast copper or ANSI/ASME B16.22 solder wrought copper.

2.5 DIELECTRIC FITTINGS

- A. Provide where copper tubing and ferrous metal pipe are joined.
- B. 50 mm (2 inches) and Smaller: Threaded dielectric union, ASME B16.39.
- C. 65 mm (2 1/2 inches) and Larger: Flange union with dielectric gasket and bolt sleeves, ASME B16.42.
- D. Temperature Rating, 99 degrees C (210 degrees F).
- E. Contractor's option: On pipe sizes 2" and smaller, screwed end brass ball valves or dielectric nipples may be used in lieu of dielectric unions.

2.6 SCREWED JOINTS

- A. Pipe Thread: ANSI B1.20.
- B. Lubricant or Sealant: Oil and graphite or other compound approved for the intended service.

2.7 VALVES

- A. Asbestos packing is not acceptable.
- B. All valves of the same type shall be products of a single manufacturer.
- C. Provide chain operators for valves 150 mm (6 inches) and larger when the centerline is located 2400 mm (8 feet) or more above the floor or operating platform.
- D. Shut-Off Valves
 - 1. Ball Valves (Pipe sizes 2" and smaller): MSS-SP 110, screwed or solder connections, brass or bronze body with chrome-plated ball with full port and Teflon seat at 2760 kPa (400 psig) working pressure rating. Provide stem extension to allow operation without interfering with pipe insulation.
 - 2. Butterfly Valves (Pipe Sizes 2-1/2" 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 or grooved end rated 1205 kPa (175 psig) working pressure at 93 degrees C (200 degrees F). Valves shall be ANSI Leakage Class VI and rated

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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. Not permitted for direct buried pipe applications.

- a. Body: Cast iron, ASTM A126, Class B. Malleable iron, ASTM A47 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.
 - c. Actuators: Field interchangeable. Valves for balancing service shall have adjustable memory stop to limit open position.
 - 1) Valves 150 mm (6 inches) and smaller: Lever actuator with minimum of seven locking positions, except where chain wheel is required.
 - 2) Valves 200 mm (8 inches) and larger: Enclosed worm gear with hand wheel, and where required, chain-wheel operator.
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. 65 mm (2 1/2 inches) and larger: Flanged, outside screw and yoke. MSS-SP 70, iron body, bronze mounted, 861 kPa (125 psig) wedge disc.

E. Globe and Angle Valves

1. Globe Valves
 - a. 50 mm (2 inches) and smaller: MSS-SP 80, bronze, 1034 kPa (150 lb.) Globe valves shall be union bonnet with metal plug type disc.
 - b. 65 mm (2 1/2 inches) and larger: 861 kPa (125 psig), flanged, iron body, bronze trim, MSS-SP-85 for globe valves.
2. Angle Valves:

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- a. 50 mm (2 inches) and smaller: MSS-SP 80, bronze, 1034 kPa (150 lb.) Angle valves shall be union bonnet with metal plug type disc.
- b. 65 mm (2 1/2 inches) and larger: 861 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 lb.), 45 degree swing disc.
- b. 65 mm (2 1/2 inches) and larger: 861 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, Class WCB, or ductile iron, ASTM 536, flanged, grooved, 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 and shut-off. Valves shall be line size rather than reduced to control valve size.

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 at least 10 times the minimum required for control. Provide standard pressure taps and four sets of capacity charts. Valves shall be line size and be one of the following designs:

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1. Gray iron (ASTM A126) or brass body rated 1205 kPa (175 psig) at 93 degrees C (200 degrees F), with stainless steel piston and spring.
2. Brass or ferrous body designed for 2067 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.

2.8 WATER FLOW MEASURING DEVICES

- A. Minimum overall accuracy plus or minus three 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. Insertion Turbine Type Sensor: Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
- D. 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 l/m (gpm).
- E. Portable Water Flow Indicating Meters:
 1. Minimum 150 mm (6 inch) diameter dial, forged brass body, beryllium-copper bellows, designed for 1205 kPa (175 psig) working pressure at 121 degrees C (250 degrees F).
 2. Bleed and equalizing valves.
 3. Vent and drain hose and two 3000 mm (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 one portable meter for each range of differential pressure required for the installed flow devices.

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- F. Permanently Mounted Water Flow Indicating Meters: Minimum 150 mm (6 inch) diameter, or 450 mm (18 inch) long scale, for 120 percent of design flow rate, direct reading in gpm, with three valve manifold and two shut-off valves.

2.9 STRAINERS

- A. Y 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 (0.125 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 (165psig) at 121 degrees C (250 degrees F).
 - b. Connector sizes 125 mm to 300 mm (5 inches to 12 inches), 965 kPa (140 psig) at 121 degrees C (250 degrees F).
 3. Provide ductile iron retaining rings and control units.

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 Standards.
- C. Bellows - Internally Pressurized Type:
1. Multiple corrugations of Type 304 or Type A240-321 stainless steel.

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2. Internal stainless steel sleeve entire length of bellows.
 3. External cast iron equalizing rings for services exceeding 340 kPa (50 psig).
 4. Welded ends.
 5. Design shall conform to standards of EJMA and ASME B31.1.
 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 B31.1.
 6. Threaded connection at bottom, 25 mm (one 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): 2415 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 grooved 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 on the contract drawings.

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- H. Guides: Provide factory-built guides along the pipe line to permit axial movement only and to restrain lateral and angular movement. Guides must 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 on the contract drawings.
- 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. Heat Exchanger (Water to Water): Shell and tube type, U-bend removable tube bundle, heating fluid in shell, heated fluid in tubes, equipped with support cradles.
 - 1. Maximum tube velocity: 2.3 m/s (7.5 feet per second).
 - 2. Tube fouling factor: TEMA Standards, but not less than 0.001.
 - 3. Materials:
 - a. Shell: Steel.
 - b. Tube sheet and tube supports: Steel or brass.
 - c. Tubes: 20 mm (3/4 inch) OD copper.
 - d. Head or bonnet: Cast iron or steel.
 - 4. Construction: In accordance with ASME Pressure Vessel Code for 861 kPa (125 psig) working pressure for shell and tubes. Provide manufacturer's certified data report, Form No. U-1. Tangential Air Separator: ASME Pressure Vessel Code 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 on the drawings, 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.
- B. Diaphragm Type Pre-Pressurized Expansion Tank: ASME Pressure Vessel Code construction for 861 kPa (125 psig) working pressure, welded steel shell, rust-proof coated, with a flexible elastomeric diaphragm suitable for a maximum operating temperature of 116 degrees C (240

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degrees F). Provide Form No. U-1. Tank shall be equipped with system connection, drain connection, standard air fill valve and be factory pre-charged to a minimum of 83 kPa (12 psig).

- 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 Code for Pressure Vessels, Section 8, and bear ASME stamp.
- E. Automatic Air Vent Valves (where shown): Cast iron or semi-steel body, 1034 kPa (150 psig) working pressure, stainless steel float, valve, valve seat and mechanism, minimum 15 mm (1/2 inch) water connection and 6 mm (1/4 inch) air outlet. Air outlet shall be piped to the nearest floor drain.

2.13 WATER FILTERS AND POT CHEMICAL FEEDERS

- A. See section 23 25 00, HVAC WATER TREATMENT, Article 2.2, CHEMICAL TREATMENT FOR CLOSED LOOP SYSTEMS.

2.14 GAGES, 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, 115 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 gages in water service.
- C. Range of Gages: Provide range equal to at least 130 percent of normal operating range.
 - 1. For condenser water suction (compound): Minus 100 kPa (30 inches Hg) to plus 700 kPa (100 psig).

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2.15 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 gage test connections shown on the drawings.
- B. Provide one each of the following test items to the Contracting Officers Representative (COR):
 - 1. 6 mm (1/4 inch) FPT by 3 mm (1/8 inch) diameter stainless steel pressure gage adapter probe for extra long test plug. PETE'S 500 XL is an example.
 - 2. 90 mm (3-1/2 inch) diameter, one percent accuracy, compound gage, -- 100 kPa (30 inches) Hg to 700 kPa (100 psig) range.
 - 3. 0 - 104 degrees C (220 degrees F) pocket thermometer one-half degree accuracy, 25 mm (one inch) dial, 125 mm (5 inch) long stainless steel stem, plastic case.

2.16 THERMOMETERS

- A. Organic liquid filled type, red or blue column, clear plastic window, with 150 mm (6 inch) brass stem, straight, fixed or adjustable angle as required for each in reading. Mercury filled thermometers are not acceptable.
- B. Case: Chrome plated brass or aluminum with enamel finish.
- C. Scale: Not less than 225 mm (9 inches), range as described below, two degree graduations.
- D. Separable Socket (Well): Brass, extension neck type to clear pipe insulation.
- E. Scale ranges:
 - 1. Chilled Water and Glycol-Water: 0-38 degrees C (32-100 degrees F).
 - 2. Hot Water and Glycol-Water: -1 - 116 degrees C (30-240 degrees F).

2.17 FIRESTOPPING MATERIAL

- A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

2.18 ELECTRICAL HEAT TRACING SYSTEMS

- A. Systems shall meet requirements of the National Electrical Code (NEC), Section 427.

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- B. Provide tracing for outdoor piping subject to freezing temperatures (Below 38 degrees F) as follows:
 - 1. Chilled water, hot water piping at AC-20 and all other areas exposed to the weather.
- C. Heat tracing shall be provided to the extent shown on the drawings (Floor plans and Elevations). Heat tracing shall extend from the conditioned space to within the custom air handling unit.
- D. Heating Cable: Flexible, parallel circuit construction consisting of a continuous self-limiting resistance, conductive inner core material between two parallel copper bus wires, designed for cut-to-length at the job site and for wrapping around valves and complex fittings. Self-regulation shall prevent overheating and burnouts even where the cable overlaps itself.
 - 1. Provide end seals at ends of circuits. Wire at the ends of the circuits is not to be tied together.
 - 2. Provide sufficient cable, as recommended by the manufacturer, to keep the pipe surface at 2.2 degrees C (36 degrees F) minimum during winter outdoor design temperature, but not less than the following:
 - a. 75 mm (3 inch) pipe and smaller with 25 mm (1 inch) thick insulation: 4 watts per foot of pipe.
 - b. 100 mm (4 inch) pipe and larger 38 mm (1-1/2 inch) thick insulation: 8 watts per feet of pipe.
- E. Electrical Heating Tracing Accessories:
 - 1. Power supply connection fitting and stainless steel mounting brackets. Provide stainless steel worm gear clamp to fasten bracket to pipe.
 - 2. 13 mm (1/2 inch) wide fiberglass reinforced pressure sensitive cloth tape to fasten cable to pipe at 300 mm (12 inch) intervals.
 - 3. Pipe surface temperature control thermostat: Cast aluminum, NEMA 4 (watertight) enclosure, 13 mm (1/2 inch) NPT conduit hub, SPST switch rated 20 amps at 480 volts AC, with capillary and copper bulb sensor. Set thermostat to maintain pipe surface temperature at not less than 1.1 degrees C (34 degrees F).

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4. Signs: Manufacturer's standard (NEC Code), stamped "ELECTRIC TRACED" located on the insulation jacket at 3000 mm (10 feet) intervals along the pipe on alternating sides.

PART 3 - EXECUTION

3.1 GENERAL

- A. The drawings 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 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 on the drawings shall be altered by contractor where necessary to avoid interferences and clearance difficulties.
- B. 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.
- C. 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.
- D. Install piping generally parallel to walls and column center lines, unless shown otherwise on the drawings. Space piping, including insulation, to provide 25 mm (one 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 (one inch) in 12 m (40 feet). Provide eccentric reducers to keep bottom of sloped piping flat.
- E. Locate and orient valves to permit proper operation and access for maintenance of packing, seat and disc. Generally locate valve stems in overhead piping in horizontal position. Provide a union adjacent to one end of all threaded end valves. Control valves usually require reducers to connect to pipe sizes shown on the drawing. Install butterfly valves

with the valve open as recommended by the manufacturer to prevent binding of the disc in the seat.

- F. Offset equipment connections to allow valving off for maintenance and repair with minimal removal of piping. Provide flexibility in equipment connections and branch line take-offs with 3-elbow swing joints where noted on the drawings.
- G. Tee water piping runouts or branches into the side of mains or other branches. Avoid bull-head tees, which are two return lines entering opposite ends of a tee and exiting out the common side.
- H. 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.
- I. Connect piping to equipment as shown on the drawings. Install components furnished by others such as:
 - 1. Water treatment pot feeders.
 - 2. Flow elements (orifice unions), control valve bodies, flow switches, pressure taps with valve, and wells for sensors.
- J. Thermometer Wells: In pipes 65 mm (2-1/2 inches) and smaller increase the pipe size to provide free area equal to the upstream pipe area.
- K. 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, PLUMBING, and BOILER PLANT INSULATION.
- L. 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 B31.1 and AWS B2.1. 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; 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. Mechanical Joint: Pipe grooving shall be in accordance with joint manufacturer's specifications. Lubricate gasket exterior including

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lips, pipe ends and housing interiors to prevent pinching the gasket during installation. Lubricant shall be as recommended by coupling manufacturer.

- D. 125 Pound Cast Iron Flange (Plain Face): Mating flange shall have raised face, if any, removed to avoid overstressing the cast iron flange.

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 must 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 LEAK TESTING ABOVEGROUND PIPING

- A. Inspect all joints and connections for leaks and workmanship and make corrections as necessary, to the satisfaction of the COR. Tests may be either of those below, or a combination, as approved by the COR.
- B. An operating test at design pressure, and for hot systems, design maximum temperature.
- C. A hydrostatic test at 1.5 times design pressure. For water systems the design maximum pressure would usually be the static head, or expansion tank maximum pressure, plus pump head. Factory tested equipment (convertors, exchangers, coils, etc.) need not be field tested. Isolate equipment where necessary to avoid excessive pressure on mechanical seals and safety devices.

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3.5 FLUSHING AND CLEANING PIPING SYSTEMS

- A. Water Piping: Clean systems as recommended by the suppliers of chemicals specified in Section 23 25 00, HVAC WATER TREATMENT.
1. 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 (6 feet per second), 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.
 2. 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 (6 feet per second). Circulate each section for not less than four hours. Blow-down all strainers, or remove and clean as frequently as necessary. Drain and prepare for final flushing.
 3. 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

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operate all valves to dislodge any debris in valve body by
throttling velocity. Flush for not less than one hour.

3.6 WATER TREATMENT

- A. Install water treatment equipment and provide water treatment system piping.
- B. Close and fill system as soon as possible after final flushing to minimize corrosion.
- C. Charge systems with chemicals specified in Section 23 25 00, HVAC WATER TREATMENT.
- D. Utilize this activity, by arrangement with the COR, for instructing VA operating personnel.

3.7 ELECTRIC HEAT TRACING

- A. Install tracing as recommended by the manufacturer.
- B. Coordinate electrical connections.

3.8 OPERATING AND PERFORMANCE TEST AND INSTRUCTION

- A. Refer to PART 3, Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Adjust red set hand on pressure gages to normal working pressure.

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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.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
D. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.
E. Section 23 21 13, HYDRONIC PIPING.
F. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION EQUIPMENT.
G. Section 26 29 11, MOTOR CONTROLLERS.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
B. 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. Curves shall be relatively flat for closed systems. 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).

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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.
 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.
- C. Allowable Vibration Tolerance for Pump Units: Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Manufacturer's Literature and Data:
 1. Pumps and accessories.
 2. Motors and drives.
 3. Variable speed motor controllers.
- C. Manufacturer's installation, maintenance and operating instructions, in accordance with Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- 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.

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1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only:
- B. American Iron and Steel Institute (AISI):
 - AISI 1045.....Cold Drawn Carbon Steel Bar, Type 1045
 - AISI 416.....Type 416 Stainless Steel
- C. American National Standards Institute (ANSI):
 - ANSI B15.1-00(R2008)..... Safety Standard for Mechanical Power Transmission Apparatus
 - ANSI B16.1-05.....Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250 and 800
- D. American Society for Testing and Materials (ASTM):
 - A48-03 (2008).....Standard Specification for Gray Iron Castings
 - B62-2009.....Standard Specification for Composition Bronze or Ounce Metal Castings
- E. Maintenance and Operating Manuals in accordance with Section 01 00 00, General Requirements.

1.6 DEFINITIONS

- A. Capacity: Liters per second (L/s) (Gallons per minute (GPM) of the fluid pumped.
- B. Head: Total dynamic head in kPa (feet) of the fluid pumped.
- C. Flat head-capacity curve: Where the shutoff head is less than 1.16 times the head at the best efficiency point.

1.7 SPARE MATERIALS

- A. Furnish one spare seal and casing gasket for each pump to the Contracting Officers Representative.

PART 2 - PRODUCTS

2.1 CENTRIFUGAL PUMPS, BRONZE FITTED

- A. General:
 - 1. Provide pumps that will operate continuously without overheating bearings or motors at every condition of operation on the pump curve, or produce noise audible outside the room or space in which installed.

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2. Provide pumps of size, type and capacity as indicated, complete with electric motor and drive assembly, unless otherwise indicated.

Design pump casings for the indicated working pressure and factory test at $1\frac{1}{2}$ times the designed pressure.

3. Provide pumps of the same type, the product of a single manufacturer, with pump parts of the same size and type interchangeable.
4. General Construction Requirements
 - a. Balance: Rotating parts, statically and dynamically.
 - b. Construction: To permit servicing without breaking piping or motor connections.
 - c. Pump Motors: Provide high efficiency motors, inverter duty for variable speed service. Refer to Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION EQUIPMENT. Motors shall be Open Drip Proof and operate at 1750 rpm unless noted otherwise.
 - d. Heating pumps shall be suitable for handling water to 225°F.
 - e. Provide coupling guards that meet ANSI B15.1, Section 8 and OSHA requirements.
 - f. Pump Connections: Flanged.
 - g. Pump shall be factory tested.
 - h. Performance: As scheduled on the Contract Drawings.

5. Variable Speed Pumps:

- a. The pumps shall be the type shown on the drawings and specified herein flex coupled to an open drip-proof motor.
- b. Variable Speed Motor Controllers: Refer to Section 26 29 11, MOTOR CONTROLLERS and to Section 23 05 11, COMMON WORK RESULTS FOR HVAC paragraph, Variable Speed Motor Controllers. Furnish controllers with pumps and motors.
- c. Pump operation and speed control shall be as shown on the drawings.

B. In-Line Type, Base Mounted End Suction or Double Suction Type:

1. Casing and Bearing Housing: Close-grained cast iron, ASTM A48.
2. Casing Wear Rings: Bronze.

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3. Suction and Discharge: Plain face flange, 850 kPa (125 psig), ANSI B16.1.
4. Casing Vent: Manual brass cock at high point.
5. Casing Drain and Gage Taps: 15 mm (1/2-inch) plugged connections minimum size.
6. Impeller: Bronze, ASTM B62, enclosed type, keyed to shaft.
7. Shaft: Steel, AISI Type 1045 or stainless steel.
8. Shaft Seal: Manufacturer's standard mechanical type to suit pressure and temperature and fluid pumped.
9. Shaft Sleeve: Bronze or stainless steel.
10. Motor: Furnish with pump. Refer to Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT.
11. Base Mounted Pumps:
 - a. Designed for disassembling for service or repair without disturbing the piping or removing the motor.
 - b. Impeller Wear Rings: Bronze.
 - c. Shaft Coupling: Non-lubricated steel flexible type or spacer type with coupling guard, ANSI B15.1, bolted to the baseplate.
 - d. Bearings (Double-Suction pumps): Regreaseable ball or roller type. Provide lip seal and slinger outboard of each bearing.
 - e. Base: Cast iron or fabricated steel for common mounting to a concrete base.
12. Provide line sized shut-off valve and suction strainer, maintain manufacturer recommended straight pipe length on pump suction (with blow down valve). Contractor option: Provide suction diffuser as follows:
 - a. Body: Cast iron with steel inlet vanes and combination diffuser-strainer-orifice cylinder with 5 mm (3/16-inch) diameter openings for pump protection. Provide taps for strainer blowdown and gage connections.
 - b. Provide adjustable foot support for suction piping.
 - c. Strainer free area: Not less than five times the suction piping.
 - d. Provide disposable start-up strainer.

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PART 3 - EXECUTION

3.1 INSTALLATION

- A. Follow manufacturer's written instructions for pump mounting and start-up. Access/Service space around pumps shall not be less than minimum space recommended by pumps manufacturer.
- B. Provide drains for bases and seals for base mounted pumps, piped to and discharging into floor drains.

3.2 START UP

- A. Coordinate location of thermometer and pressure gauges as per Section 23 21 13, HYDRONIC PIPING START-UP
- B. Verify that the piping system has been flushed, cleaned and filled.
- C. Lubricate pumps before start-up.
- D. 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.
- E. Verify that correct size heaters-motor over-load devices are installed for each pump controller unit.
- F. Field modifications to the bearings and or impeller (including trimming) are not permitted. 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.
- G. Ensure the disposable strainer is free of debris prior to testing and balancing of the hydronic system.
- H. After several days of operation, replace the disposable start-up strainer with a regular strainer in the suction diffuser.

- - - E N D - - -

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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.

1.2 RELATED WORK

- A. General mechanical requirements and items, which are common to more than one section of Division 23: Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Pumps: Section 23 22 23, STEAM CONDENSATE PUMPS.
- C. Piping insulation: Section 23 07 11, HVAC, PLUMBING, AND BOILER PLANT INSULATION.
- D. Water treatment for open and closed systems: Section 23 25 00, HVAC WATER TREATMENT.
- E. Heating Coils and Humidifiers: Section 23 73 43, CUSTOM, INDOOR CENTRAL-STATION AIR-HANDLING UNITS, Section 23 74 43, CUSTOM, OUTDOOR CENTRAL-STATION AIR-HANDLING UNITS and SECTION 23 31 00, HVAC DUCTS AND CASING.
- F. Heating coils: Section 23 82 16, AIR COILS.
- G. Temperature and pressure sensors and valve operators: Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

1.3 QUALITY ASSURANCE

- A. Section 23 05 11, COMMON WORK RESULTS FOR HVAC, which includes welding qualifications.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Manufacturer's Literature and Data:
 - 1. Pipe and equipment supports.
 - 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. Strainers.

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7. Pipe alignment guides.
 8. Expansion joints.
 9. Expansion compensators.
 10. Flexible ball joints: Catalog sheets, performance charts, schematic drawings, specifications and installation instructions.
 11. All specified steam system components.
 12. Gages.
 13. Thermometers and test wells.
 14. Electric heat tracing systems.
 15. Seismic bracing details for piping.
- C. Manufacturer's certified data report, Form No. U-1, for ASME pressure vessels:
1. Heat Exchangers (Steam-to-Hot Water).
 2. Flash tanks.
- D. Coordination Drawings: Refer to Article, 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.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American Society of Mechanical Engineers/American National Standards Institute (ASME/ANSI):
- B1.20.1-83(R2006).....Pipe Threads, General Purpose (Inch)
- B16.4-2006.....Gray Iron Threaded Fittings
- C. American Society of Mechanical Engineers (ASME):
- B16.1-2005.....Gray Iron Pipe Flanges and Flanged Fittings
- B16.3-2006.....Malleable Iron Threaded Fittings
- B16.9-2007.....Factory-Made Wrought Buttwelding Fittings

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B16.11-2005.....Forged Fittings, Socket-Welding and Threaded
B16.14-91.....Ferrous Pipe Plugs, Bushings, and Locknuts with
Pipe Threads
B16.22-2001.....Wrought Copper and Copper Alloy Solder-Joint
Pressure Fittings
B16.23-2002.....Cast Copper Alloy Solder Joint Drainage
Fittings
B16.24-2006.....Cast Copper Alloy Pipe Flanges and Flanged
Fittings, Class 150, 300, 400, 600, 900, 1500
and 2500
B16.39-98.....Malleable Iron Threaded Pipe Unions, Classes
150, 250, and 300
B31.1-2007.....Power Piping
B31.9-2008.....Building Services Piping
B40.100-2005.....Pressure Gauges and Gauge Attachments
Boiler and Pressure Vessel Code: SEC VIII D1-2001, Pressure Vessels,
Division 1

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

A47-99.....Ferritic Malleable Iron Castings
A53-2007.....Pipe, Steel, Black and Hot-Dipped, Zinc-Coated,
Welded and Seamless
A106-2008.....Seamless Carbon Steel Pipe for High-Temperature
Service
A126-2004.....Standard Specification for Gray Iron Castings
for Valves, Flanges, and Pipe Fittings
A181-2006.....Carbon Steel Forgings, for General-Purpose
Piping
A183-2003 Carbon Steel Track Bolts and Nuts
A216-2008 Standard Specification for Steel Castings,
Carbon, Suitable for Fusion Welding, for High
Temperature Service
A285-01 Pressure Vessel Plates, Carbon Steel, Low-and-
Intermediate-Tensile Strength
A307-2007 Carbon Steel Bolts and Studs, 60,000 PSI Tensile
Strength

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- A516-2006 Pressure Vessel Plates, Carbon Steel, for
Moderate-and- Lower Temperature Service
- A536-84(2004)e1 Standard Specification for Ductile Iron Castings
- B32-2008 Solder Metal
- B61-2008 Steam or Valve Bronze Castings
- B62-2009 Composition Bronze or Ounce Metal Castings
- B88-2003 Seamless Copper Water Tube
- F439-06 Socket-Type Chlorinated Poly (Vinyl Chloride)
(CPVC) Plastic Pipe Fittings, Schedule 80
- F441-02(2008) Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic
Pipe, Schedules 40 and 80
- E. American Welding Society (AWS):
- A5.8-2004.....Filler Metals for Brazing and Braze Welding
- B2.1-00.....Welding Procedure and Performance
Qualifications
- F. Manufacturers Standardization Society (MSS) of the Valve and Fitting
Industry, Inc.:
- SP-67-95.....Butterfly Valves
- SP-70-98.....Cast Iron Gate Valves, Flanged and Threaded
Ends
- SP-71-97.....Gray Iron Swing Check Valves, Flanged and
Threaded Ends
- SP-72-99.....Ball Valves with Flanged or Butt-Welding Ends
for General Service
- SP-78-98.....Cast Iron Plug Valves, Flanged and Threaded
Ends
- SP-80-97.....Bronze Gate, Globe, Angle and Check Valves
- SP-85-94.....Cast Iron Globe and Angle Valves, Flanged and
Threaded Ends
- G. Military Specifications (Mil. Spec.):
- MIL-S-901D-1989.....Shock Tests, H.I. (High Impact) Shipboard
Machinery, Equipment, and Systems

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H. National Board of Boiler and Pressure Vessel Inspectors (NB): Relieving Capacities of Safety Valves and Relief Valves

I. Tubular Exchanger Manufacturers Association: TEMA 18th Edition, 2000

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, Grade B, seamless or ERW; A106 Grade B, Seamless; Schedule 40.

B. Steam Condensate and Pumped Condensate Piping:

1. Concealed above ceiling, in wall or chase: Copper water tube ASTM B88, Type K, hard drawn.

2. All other locations: Copper water tube ASTM B88, Type K, hard drawn; or steel, ASTM A53, Grade B, Seamless or ERW, or A106 Grade B Seamless, Schedule 80.

C. Low and Medium Pressure Clean Untreated Steam (316 Stainless Steel):

1. Pipe 2 inches and smaller: ASTM A312, TP 316, Schedule 40, seamless stainless steel.

a. Fittings: ASTM A351, 150#, Gr. F316, ANSI B1.20.1, 3000 lb. socket-weld.

b. Unions: 3000 lb socket-weld, stainless steel ground joint, ASTM B16.39.

2. Pipe 2-1/2 inches and larger: ASTM A312, TP 316, Schedule 40, seamless stainless steel.

a. Fittings: ASTM A351, 150#, Gr. WP316/ANSI 16.3, Butt-weld.

b. Unions: None

c. Flanges: ASTM A351, 150#, Gr. F316, ANSI B16.5, 150 lb. standard with 1/16 inch raised face, serrated face finish and welding neck.

d. Bolts: Stud bolts, ASTM A193, Gr. B7.

e. Nuts: ASTM A194, Gr. 2H.

D. Vent Piping: Steel, ASTM A53, Grade B, seamless or ERW; A106 Grade B, Seamless; Schedule 40, galvanized.

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2.3 FITTINGS FOR STEEL PIPE

- A. 50 mm (2 inches) and Smaller: Screwed or welded.
 - 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, except for steam and steam condensate piping. Provide 300 pound malleable iron, ASME B16.3 for steam and steam condensate piping. Cast iron fittings or piping is not acceptable for steam and steam condensate piping. Bushing reduction of a single pipe size, or use of close nipples, is not acceptable.
 - 4. Unions: ASME B16.39.
 - 5. Steam line drip station and strainer quick-couple blowdown hose connection: Straight through, plug and socket, screw or cam locking type for 15 mm (1/2 inch) ID hose. No integral shut-off is required.
- B. 65 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. 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 psi.
 - 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 may be used for branch connections up to one pipe size smaller than the main. Forged steel half-couplings, ASME B16.11 may be used for drain, vent and gage connections.

2.4 FITTINGS FOR COPPER TUBING

- A. Solder Joint:

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1. Joints shall be made up in accordance with recommended practices of the materials applied. Apply 95/5 tin and antimony on all copper piping.

B. Bronze Flanges and Flanged Fittings: ASME B16.24.

C. Fittings: ANSI/ASME B16.18 cast copper or ANSI/ASME B16.22 solder wrought copper.

2.5 DIELECTRIC FITTINGS

A. Provide where copper tubing and ferrous metal pipe are joined.

B. 50 mm (2 inches) and Smaller: Threaded dielectric union, ASME B16.39.

C. 65 mm (2 1/2 inches) and Larger: Flange union with dielectric gasket and bolt sleeves, ASME B16.42.

D. Temperature Rating, 121 degrees C (250 degrees F) for steam condensate and as required for steam service.

E. Contractor's option: On pipe sizes 2" and smaller, screwed end brass gate valves may be used in lieu of dielectric unions.

2.6 SCREWED JOINTS

A. Pipe Thread: ANSI B1.20.

B. Lubricant or Sealant: Oil and graphite or other compound approved for the intended service.

2.7 VALVES

A. Asbestos packing is not acceptable.

B. All valves of the same type shall be products of a single manufacturer.

C. Provide chain operators for valves 150 mm (6 inches) and larger when the centerline is located 2100 mm (7 feet) or more above the floor or operating platform.

D. Shut-Off Valves

1. Gate Valves:

a. 50 mm (2 inches) and smaller: MSS-SP80, Bronze, 1034 kPa (150 lb.), wedge disc, rising stem, union bonnet.

b. 65 mm (2 1/2 inches) and larger: Flanged, outside screw and yoke.

1) High pressure steam 413 kPa (60 psig) and above nominal MPS system): Cast steel body, ASTM A216 grade WCB, 1034 kPa (150 psig) at 260 degrees C (500 degrees F), 11-1/2 to 13 percent chrome stainless steel solid disc and seats. Provide 25 mm

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(1 inch) factory installed bypass with globe valve on valves
100 mm (4 inches) and larger.

- 2) All other services: MSS-SP 70, iron body, bronze mounted,
861 kPa (125 psig) wedge disc.

E. Globe and Angle Valves:

1. Globe Valves:

- a. 50 mm (2 inches) and smaller: MSS-SP 80, bronze, 1034 kPa (150
lb.) Globe valves shall be union bonnet with metal plug type
disc.
- b. 65 mm (2 1/2 inches) and larger:
 - 1) Globe valves for high pressure steam 413 kPa (60 psig) and
above nominal MPS system): Cast steel body, ASTM A216 grade
WCB, flanged, OS&Y, 1034 kPa (150 psig) at 260 degrees C
(500 degrees F), 11-1/2 to 13 percent chrome stainless steel
disc and renewable seat rings.
 - 2) All other services: 861 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
lb.) Angle valves shall be union bonnet with metal plug type
disc.
- b. 65 mm (2 1/2 inches) and larger:
 - 1) Angle valves for high pressure steam 413 kPa (60 psig) and
above nominal MPS system): Cast steel body, ASTM A216 grade
WCB, flanged, OS&Y, 1034 kPa (150 psig) at 260 degrees C
(500 degrees F), 11-1/2 to 13 percent chrome stainless steel
disc and renewable seat rings.
 - 2) All other services: 861 kPa (125 psig), flanged, iron body,
bronze trim, MSS-SP-85 for angle valves.

F. Swing Check Valves

1. 50 mm (2 inches) and smaller: MSS-SP 80, bronze, 1034 kPa (150
psig), 45 degree swing disc.
2. 65 mm (2-1/2 inches) and Larger:
 - a. Check valves for high pressure steam 413 kPa (60 psig) and
above nominal MPS system: Cast steel body, ASTM A216 grade

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WCB, flanged, OS&Y, 1034 kPa (150 psig) at 260 degrees C (500 degrees F), 11-1/2 to 13 percent chrome stainless steel disc and renewable seat rings.

b. All other services: 861 kPa (125 psig), flanged, iron body, bronze trim, MSS-SP-71 for check valves.

G. Manual Radiator/Convactor Valves: Brass, packless, with position indicator.

2.8 STRAINERS

A. Basket or Y Type. Tee type is acceptable for gravity flow and pumped steam condensate service.

B. High Pressure Steam: Rated 1034 kPa (150 psig) saturated steam.

1. 50 mm (2 inches) and smaller: Iron, ASTM A116 Grade B, or bronze, ASTM B-62 body with screwed connections (250 psig).

2. 65 mm (2-1/2 inches) and larger: Flanged cast steel or 1723 kPa (250 psig) cast iron.

C. All Other Services: Rated 861 kPa (125 psig) saturated steam.

1. 50 mm (2 inches) and smaller: Cast iron or bronze.

2. 65 mm (2-1/2 inches) and larger: Flanged, iron 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. 75 mm (3 inches) and smaller: 20 mesh for steam and 1.1 mm (0.045 inch) diameter perforations for liquids.

2. 100 mm (4 inches) and larger: 1.1 mm (0.045) inch diameter perforations for steam and 3.2 mm (0.125 inch) diameter perforations for liquids.

2.9 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 must 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 on the contract drawings.

2.10 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

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located along the pipe lines to restrain lateral pipe motion and direct the axial pipe movement into the expansion joints.

B. Minimum Service Requirements:

1. Pressure Containment:

- a. Steam Service 35-200 kPa (5-30 psig): Rated 345 kPa (50 psig) at 148 degrees C (298 degrees F).
- b. Steam Service 214-850 kPa (31-125 psig): Rated 1025 kPa (150 psig) at 186 degrees C (366 degrees F).
- c. Steam Service 869-1025 kPa (126-150 psig): Rated 1375 kPa (200 psig) at 194 degrees C (382 degrees F).
- d. Condensate Service: Rated 690 kPa (100 psig) at 154 degrees C (310 degrees F).

2. Number of Full Reverse Cycles without failure: Minimum 1000.

3. Movement: As shown on drawings plus recommended safety factor of manufacturer.

C. Manufacturing Quality Assurance: Conform to Expansion Joints Manufacturers Association Standards.

D. 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 340 kPa (50 psig).
4. Welded ends.
5. Design shall conform to standards of EJMA and ASME B31.1.
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.

E. 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 B31.1.

6. Threaded connection at bottom, 25 mm (one inch) minimum, for drain or drip point.

7. Integral external cover and internal sleeve.

F. 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 on the contract drawings.

2.11 FLEXIBLE BALL JOINTS

A. Design and Fabrication: One piece component construction, fabricated from steel with welded ends, designed for a working steam pressure of 1720 kPa (250 psig) and a temperature of 232 degrees C (450 degrees F). Each joint shall provide for 360 degrees rotation in addition to a minimum angular flexible movement of 30 degrees for sizes 6 mm (1/4 inch) to 150 mm (6 inch) inclusive, and 15 degrees for sizes 65 mm (2-1/2 inches) to 750 mm (30 inches). Joints through 350 mm (14 inches) shall have forged pressure retaining members; while size 400 mm (16 inches) through 760 mm (30 inches) shall be of one piece construction.

B. Material:

1. Cast or forged steel pressure containing parts and bolting in accordance with Section II of the ASME Boiler Code or ASME B31.1. Retainer may be ductile iron ASTM A536, Grade 65-45-12, or ASME Section II SA 515, Grade 70.
2. Gaskets: Steam pressure molded composition design for a temperature range of from minus 10 degrees C (50 degrees F) to plus 274 degrees C (525 degrees F).

C. Certificates: Submit qualifications of ball joints in accordance with the following test data:

1. Low pressure leakage test: 41 kPa (6psig) saturated steam for 60 days.
2. Flex cycling: 800 Flex cycles at 3445 kPa (500 psig) saturated steam.
3. Thermal cycling: 100 saturated steam pressure cycles from atmospheric pressure to operating pressure and back to atmospheric pressure.

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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 axis at 25 to 125 Hz; 1.3 mm to 2.5 mm (0.05 inch to 0.1 inch) double amplitude on a single ball joint and 3 ball joint off set.

2.12 STEAM SYSTEM COMPONENTS

- A. Heat Exchanger (Steam to Hot Water): Shell and tube type, U-bend removable tube bundle, steam in shell, water in tubes, equipped with support cradles.
 1. Maximum tube velocity: 2.3 m/s (7.5 feet per second).
 2. Tube fouling factor: TEMA Standards, but not less than $0.00018 \text{ m}^2\text{K/W}$ ($0.001 \text{ ft}^2\text{hrF/Btu}$).
 3. Materials:
 - a. Shell: Steel.
 - b. Tube sheet and tube supports: Steel or brass.
 - c. Tubes: 20 mm (3/4 inch) OD copper.
 - d. Head or bonnet: Cast iron or steel.
 4. Construction: In accordance with ASME Pressure Vessel Code for 861 kPa (125 psig) working pressure for shell and tubes. Provide manufacturer's certified data report, Form No. U-1.
- B. Optional Heat Transfer Package: In lieu of field erected individual components, the Contractor may provide a factory or shop assembled package of heat exchangers, pumps, and other components supported on a welded steel frame.
- C. Steam Pressure Reducing Valves in PRV Stations:
 1. Type: Single-seated, diaphragm operated, spring-loaded, external or internal steam pilot-controlled, normally closed, adjustable set pressure. Pilot shall sense controlled pressure downstream of main valve.
 2. Service: Provide controlled reduced pressure to steam piping systems.
 3. Pressure control shall be smooth and continuous with maximum drop of 10 percent. Maximum flow capability of each valve shall not exceed capacity of downstream safety valve(s).

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4. Main valve and pilot valve shall have replaceable valve plug and seat of stainless steel, monel, or similar durable material.
 - a. Pressure rating for high pressure steam: Not less than 1034 kPa (150 psig) saturated steam.
 - b. Connections: Flanged for valves 65 mm (2-1/2 inches) and larger; flanged or threaded ends for smaller valves.
5. Select pressure reducing valves to develop less than 85 dbA at 1500 mm (5 feet) elevation above adjacent floor, and 1500 mm (5 feet) distance in any direction. Inlet and outlet piping for steam pressure reducing valves shall be Schedule 80 minimum for required distance to achieve required levels or sound attenuators shall be applied.
- D. Safety Valves and Accessories: Comply with ASME Boiler and Pressure Vessel Code, 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.
- E. Steam PRV for Individual Equipment: Cast iron or bronze body, screwed or flanged ends, rated 861 kPa (125 psig) working pressure. Single-seated, diaphragm operated, spring loaded, adjustable range, all parts renewable.
- F. Flash Tanks: Horizontal or vertical vortex type, constructed of copper bearing steel, ASTM A516 or ASTM A285, for a steam working pressure of 861 kPa (125 psig) to comply with ASME Code for Unfired Pressure Vessels and stamped with "U" symbol. Perforated pipe inside tank shall be ASTM A53 Grade B, Seamless or ERW, or A106 Grade B Seamless, Schedule 80. Corrosion allowance of 1.6 mm (1/16 inch) may be provided in lieu of the copper bearing requirement. Provide data Form No. U-1.
- G. Steam Trap: Each type of trap shall be the product of a single manufacturer. Provide trap sets at all low points and at 61 m (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 on the drawings, traps shall be sized for capacities indicated at minimum pressure drop as follows:

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- a. For equipment with modulating control valve: 1.7 kPa (1/4 psig), based on a condensate leg of 300 mm (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: Bronze, cast iron, or semi-steel, constructed to permit ease of removal and servicing working parts without disturbing connecting piping. For systems without relief valve, traps shall be 5. Mechanism: Brass, stainless steel or corrosion resistant alloy. rated for the pressure upstream of the PRV 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. Floats: Stainless steel.
6. Inverted bucket traps: Provide bi-metallic thermostatic element for rapid release of non-condensables.
- H. Thermostatic Air Vent (Steam): Brass or iron body, balanced pressure bellows, stainless steel (renewable) valve and seat, rated 861 kPa (125 psig) working pressure, 20 mm (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.
- I. Steam Humidifiers:
 1. Steam separator type that discharges steam into air stream through a steam jacketed distribution manifold or dispersion tube. Humidifiers shall be complete with Y-type steam supply strainer; modulating, normally closed steam control valve; normally closed condensate temperature switch; and manufacturer's standard steam trap.
 2. Steam separator: Stainless steel or cast iron.
 3. 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:
 - a. Duct section height exceeds 900 mm (36 inches).
 - b. Duct air velocity exceeds 5.1 m/s (1000 feet per minute).

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c. If within 900 mm (3 feet) upstream of fan, damper or pre-filter.

d. If within 3000 mm (10 feet) upstream of after-filter.

J. Steam Flow Meter/Recorder: Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

K. Steam Exhaust Head: Cast iron, fitted with baffle plates, to trap and drain condensed water.

2.13 GAGES, PRESSURE AND COMPOUND

A. ASME B40.1, Accuracy Grade 1A, (pressure, vacuum, or compound), initial mid-scale accuracy 1 percent of scale (Qualify grade), metal or phenolic case, 115 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 gages in water service. Provide brass pigtail syphon for steam gages.

C. Range of Gages: For services not listed provide range equal to at least 130 percent of normal operating range:

Low pressure steam and steam condensate to 103 kPa(15 psig)	0 to 207 kPa (30 psig).
Medium pressure steam and steam condensate nominal 413 kPa (60 psig)	0 to 689 kPa (100 psig).
High pressure steam and steam condensate nominal 620 kPa to 861 kPa (90 to 125 psig)	0 to 1378 kPa (200 psig).
Pumped condensate, steam condensate, gravity or vacuum (30" HG to 30 psig)	0 to 415 kPa (60 psig)

2.14 PRESSURE/TEMPERATURE TEST PROVISIONS

A. Provide one each of the following test items to the Contracting Officers Representative (COR):

1. 6 mm (1/4 inch) FPT by 3 mm (1/8 inch) diameter stainless steel pressure gage adapter probe for extra-long test plug. PETE'S 500 XL is an example.

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2. 90 mm (3-1/2 inch) diameter, one percent accuracy, compound gage, 762 mm (30 inches) Hg to 689 kPa (100 psig) range.
3. 0 - 104 degrees C (32-220 degrees F) pocket thermometer one-half degree accuracy, 25 mm (one inch) dial, 125 mm (5 inch) long stainless steel stem, plastic case.

2.15 FIRESTOPPING MATERIAL

- A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

2.16 ELECTRICAL HEAT TRACING SYSTEMS

- A. Systems shall meet requirements of the National Electrical Code (NEC), Section 427.
- B. Provide tracing for outdoor piping subject to freezing temperatures (Below 38 degrees F) as follows:
 1. Steam piping exposed to weather.
 2. Steam condensate exposed to weather.
- C. Heat tracing shall be provided to the extent shown on the drawings (Floor Plans and Elevations). Heat tracing shall extend from the conditioned space to within AC-20.
- D. Heating Cable: Flexible, parallel circuit construction consisting of a continuous self-limiting resistance, conductive inner core material between two parallel copper bus wires, designed for cut-to-length at the job site and for wrapping around valves and complex fittings. Self-regulation shall prevent overheating and burnouts even where the cable overlaps itself.
 1. Provide end seals at ends of circuits. Wires at the ends of the circuits are not to be tied together.
 2. Provide sufficient cable, as recommended by the manufacturer, to keep the pipe surface at 2.2 degrees C (36 degrees F) minimum during winter outdoor design temperature, but not less than the following:
 - a. 75 mm (3 inch) pipe and smaller with 25 mm (1 inch) thick insulation: 4 watts per foot of pipe.
 - b. 100 mm (4 inch) pipe and larger 38 mm (1-1/2 inch) thick insulation: 8 watts per feet of pipe.
- E. Electrical Heating Tracing Accessories:

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1. Power supply connection fitting and stainless steel mounting brackets. Provide stainless steel worm gear clamp to fasten bracket to pipe.
2. 13 mm (1/2 inch) wide fiberglass reinforced pressure sensitive cloth tape to fasten cable to pipe at 300 mm (12 inch) intervals.
3. Pipe surface temperature control thermostat: Cast aluminum, NEMA 4 (watertight) enclosure, 13 mm (1/2 inch) NPT conduit hub, SPST switch rated 20 amps at 480 volts AC, with capillary and copper bulb sensor. Set thermostat to maintain pipe surface temperature at not less than 1.1 degrees C (34 degrees F).
4. Signs: Manufacturer's standard (NEC Code), stamped "ELECTRIC TRACED" located on the insulation jacket at 3000 mm (10 feet) intervals along the pipe on alternating sides.

PART 3 - EXECUTION

3.1 GENERAL

- A. The drawings 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 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 on the drawings shall be altered by contractor where necessary to avoid interferences and clearance difficulties.
- B. 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.
- C. 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.
- D. Install piping generally parallel to walls and column center lines, unless shown otherwise on the drawings. Space piping, including insulation, to provide 25 mm (one inch) minimum clearance between

adjacent piping or other surface. Unless shown otherwise, slope steam, condensate and drain piping down in the direction of flow not less than 25 mm (one inch) in 12 m (40 feet). Provide eccentric reducers to keep bottom of sloped piping flat.

- E. Locate and orient valves to permit proper operation and access for maintenance of packing, seat and disc. Generally locate valve stems in overhead piping in horizontal position. Provide a union adjacent to one end of all threaded end valves. Control valves usually require reducers to connect to pipe sizes shown on the drawing. Install butterfly valves with the valve open as recommended by the manufacturer to prevent binding of the disc in the seat.
- F. Offset equipment connections to allow valving off for maintenance and repair with minimal removal of piping. Provide flexibility in equipment connections and branch line take-offs with 3-elbow swing joints where noted on the drawings.
- G. Tee water piping runouts or branches into the side of mains or other branches. Avoid bull-head tees, which are two return lines entering opposite ends of a tee and exiting out the common side.
- H. Connect piping to equipment as shown on the drawings. Install components furnished by others such as:
- I. Flow elements (orifice unions), control valve bodies, flow switches, pressure taps with valve, and wells for sensors.
- J. 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, PLUMBING, and BOILER PLANT INSULATION.
- K. Where copper piping is connected to steel piping, provide dielectric connections.
- L. 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 one inch in 40 feet (0.25 percent) in direction of flow. Provide a drip trap elbow on relief valve outlets if the vent rises to prevent backpressure. Terminate vent minimum 0.3 M (12 inches) above the roof or through the wall minimum 2.5 M (8 feet) above grade with down turned elbow.

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3.2 PIPE JOINTS

- A. Welded: Beveling, spacing and other details shall conform to ASME B31.1 and AWS B2.1. 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; joint compound shall be applied to male threads only and joints made up so no more than three threads show. Coat exposed threads on steel pipe with joint compound, or red lead paint for corrosion protection.
- C. 125 Pound Cast Iron Flange (Plain Face): Mating flange shall have raised face, if any, removed to avoid overstressing the cast iron flange.

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 must 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 packing.

3.4 STEAM TRAP PIPING

- A. Install to permit gravity flow to the trap. Provide gravity flow (avoid lifting condensate) from the trap where modulating control valves are used. Support traps weighing over 11 kg (25 pounds) independently of connecting piping.

3.5 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.

3.6 CLEANING AND FLUSHING OF STEAM SYSTEMS

- A. Clean piping systems thoroughly. Purge pipe of construction debris and contamination before placing the systems in service. Provide whatever temporary connections are required for cleaning, purging and circulating.
- B. Install temporary strainers in front of pumps, tanks, water still, solenoid valves, control valves and other equipment where permanent strainers are not indicated. Where permanent strainers are indicated, assure that the strainers are installed and screens are in place and are cleaned. Keep temporary strainers in service until the equipment has been tested, then replace straining element with a new strainer and clean and deliver the old straining elements to owner. Fit strainers with a line size blow-off valve.
- C. Circulate a chemical cleaner in steam and condensate piping system to remove mill scale, grease, oil and silt. Circulate chemical cleaner for 48 hours, flush system and replace with clean water. Dispose of chemical solution in accordance with local codes. When the chemical cleaning is complete, remove, clean and reinstall all permanent screens. Notify owner so that the reinstallation of clean strainer screens may be witnessed.

3.7 OPERATING AND PERFORMANCE TEST AND INSTRUCTION

- A. Refer to PART 3, Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Adjust red set hand on pressure gages to normal working pressure.

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SECTION 23 22 23
STEAM CONDENSATE PUMPS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Steam condensate pumps for Heating, Ventilating and Air Conditioning.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
D. Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.
E. Section 23 22 13, STEAM AND CONDENSATE HEATING PIPING.
F. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION EQUIPMENT.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALITY ASSURANCE in Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.
- B. 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. Select pumps so that required net positive suction head (NPSHR) does not exceed the net positive head available (NPSHA).
 4. Pump Driver: Furnish with pump. Size shall be non-overloading at any point on the head-capacity curve including one pump operation in a parallel or series pumping installation.
 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.

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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.
9. Furnish one spare seal and casing gasket for each pump to the Contracting Officers Representative (COR).
- C. Allowable Vibration Tolerance for Pump Units: Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Manufacturer's Literature and Data:
 1. Pumps and accessories.
 2. Motors and drives.
- C. Manufacturer's installation, maintenance and operating instructions, in accordance with Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.
- D. Characteristic Curves: Head-capacity, efficiency-capacity, brake horsepower-capacity, and NPSHR-capacity for each pump.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only:
- B. American Iron and Steel Institute (AISI):
AISI 1045.....Cold Drawn Carbon Steel Bar, Type 1045
AISI 416.....Type 416 Stainless Steel
- C. American National Standards Institute (ANSI):
ANSI B15.1-00(R2008)....Safety Standard for Mechanical Power
Transmission Apparatus
ANSI B16.1-05.....Cast Iron Pipe Flanges and Flanged Fittings,
Class 25, 125, 250 and 800
- D. American Society for Testing and Materials (ASTM):
A48-03(2008).....Standard Specification for Gray Iron Castings

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B62-09.....Standard Specification for Composition Bronze
or Ounce Metal Castings

E. Maintenance and Operating Manuals in accordance with Section 01 00 00,
GENERAL REQUIREMENTS.

1.6 DEFINITIONS

A. Capacity: Liters per second (L/s) (Gallons per minute (GPM)) of the
fluid pumped.

B. Head: Total dynamic head in kPa (feet) of the fluid pumped.

PART 2 - PRODUCTS

2.1 PRESSURE POWERED CONDENSATE PUMP

A. Pressure-Powered Pump Packages:

1. Pump packages shall be furnished and installed as a packaged
assembly of the types, sizes, capacities, and characteristics as
shown on the drawings. Pump package shall be rated for 185 degrees
C (365 degrees F), maximum condensate temperatures.

2. Pump package(s) shall come completely piped and mounted on a steel
skid including (1) receiver/reservoir, two positive displacement
pressure-powered pumps as scheduled, interconnecting piping and
valves, and all accessories as hereafter specified below:

a. The receiver shall be of a steel elevated design, warranted
for 1 year against defects in material and workmanship.
Receiver shall be 150 PSIG ASME labeled and coded. Receiver
shall be sized for the required condensate storage volume and
flash steam capacity. Receiver shall be horizontally mounted
and have openings of the appropriate size and number
including: (2) inlets, (1) vent opening, (1) NPT drain with
pipe plug, (1) NPT anode opening with anode, and gauge glass
openings with gauge glass set consisting of (2) brass
isolation valves and guard rods, and red-line tubular glass.
Replaceable magnesium anode, which retards the corrosive
action of most waters and adds to the service life of the
tanks, shall be furnished with each receiver for corrosion
protection.

b. Pressure-powered pumps shall be non-electric as shown on the
drawings. Units shall be constructed of 1034 kPa (150 psig)

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ASME labeled and coded fabricated steel body, shall be float operated, and contain a condensate inlet baffle. Each unit shall have (1) inlet check valve, (1) outlet check valve, and gauge glass set with isolation valves.

- c. The float operating mechanism shall have all moving components constructed of stainless steel and be of a snap acting design with no external seals or packing. The float mechanism shall contain a reinforced stainless steel float, (2) 300 series stainless steel open coil design springs, and spring calibration pins.
- d. Pressure-powered pumps shall be of a non-cavitating design capable of operation on systems up to the maximum working pressure of the tank rating using steam, compressed air, or other compatible inert gas as the supply (motive) pressure. Units shall be capable of operating at temperatures up to 365 F when pumping from a 'closed' system using a compatible motive gas. Balance and fine tune motive pressure to be 138 kPa (20 psig) higher than the static backpressure.
- e. Package shall include interconnecting piping between receiver/reservoir and the positive displacement pressure-powered pump(s). Interconnecting suction (fill) line shall be provided to each unit and each suction (fill) line shall include a gate valve for isolation.
- f. Manufacturer shall provide the following for field installation on each pressure-powered pump:
 - 1) Cycle counter
 - 2) Removable insulation jacket
 - 3) Pressure gauge
 - 4) Drain piping
- g. Provide the following components for each pump:
 - 1) Motive pressure reducing valve
 - 2) Safety relief valve(s)
 - 3) Motive pressure inlet strainer
 - 4) Pressure gauge with pigtail, as required
 - 5) Motive pressure drip trap(s)

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- 6) Motive pressure line check valve(s)
3. The package shall be factory tested as a complete unit using steam as the motive pressure. The pump manufacturer shall furnish appropriate assembly and parts drawings, and installation and operation manuals. The package shall be shipped completely assembled, or with connection match marks if package must be shipped as sub-assemblies.
- B. Removable Insulation Jacket:
 1. The insulation jacket should be of sewn construction with Velcro fasteners and have openings for inlet, outlet, drain, and gauge glass.
 2. Materials:
 - a. Liner and jacket shall be silicone impregnated heavy duty glass fiber rated for a maximum temperature of 260 degrees C (500 degrees F).
 - b. Insulation shall be 25 mm (1 inch) minimum thickness, Type E needled glass fiber mat rated for a maximum temperature of 650 degrees C (1200 F).
 - c. Jacket shall be sewn with Nomex thread with a UV inhibitor.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Follow manufacturer's written instructions for pump mounting and start-up. Access/Service space around pumps shall not be less than minimum space recommended by pumps manufacturer.
- B. Permanently support in-line pumps by the connecting piping only, not from the casing or the motor eye bolt.
- C. Sequence of installation for base-mounted pumps:
 1. Level and shim the unit base and grout to the concrete pad.
 2. Shim the driver and realign the pump and driver. Correct axial, angular or parallel misalignment of the shafts.
 3. Connect properly aligned and independently supported piping.
 4. Recheck alignment.
- D. Pad-mounted Condensate Pump: Level, shim, bolt, and grout the unit base onto the concrete pad.

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- E. Coordinate location of thermometer and pressure gauges as per Section 23 22 13, STEAM and CONDENSATE HEATING PIPING.

3.2 START-UP

- A. Verify that the piping system has been flushed, cleaned and filled.
- B. Lubricate pumps before start-up.
- C. 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.
- D. Verify that correct size heaters-motor over-load devices are installed for each pump controller unit.
- E. Field modifications to the bearings and or impeller (including trimming) are not permitted. 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.

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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. 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. 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 23 05 11, COMMON WORK RESULTS FOR HVAC.
- C. Section 23 07 11, HVAC, and BOILER PLANT INSULATION.
- D. Section 23 21 13, HYDRONIC PIPING.

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. The application of this Code is intended to assure the safe design, construction, installation, operation, and inspection of

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every refrigerating system employing a fluid which normally is vaporized and liquefied in its refrigerating cycle.

- C. Comply with ASME B31.5: Refrigerant Piping and Heat Transfer Components.
- D. Products shall comply with UL 207 "Refrigerant-Containing Components and Accessories, "Nonelectrical"; or UL 429 "Electrical Operated Valves."

1.4 SUBMITTALS

- A. Submit in accordance with specification Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Shop Drawings:
 - 1. Complete information for components noted, including valves and refrigerant piping accessories, clearly presented, shall be included to determine compliance with drawings and specifications for components noted below:
 - a. Tubing and fittings
 - b. Valves
 - c. Strainers
 - d. Moisture-liquid indicators
 - e. Filter-driers
 - f. Flexible metal hose
 - g. Liquid-suction interchanges
 - h. Oil separators (when specified)
 - i. Gages
 - 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.
- C. Certification: Copies of certificates for welding procedure, performance qualification record and list of welders' names and symbols.

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1.5 APPLICABLE PUBLICATIONS

F. American Society for Testing and Materials (ASTM)

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A126-04.....Standard Specification for Gray Iron Castings
for Valves, Flanges, and Pipe FittingsB32-08

Standard Specification for Solder Metal

B88-03.....Standard Specification for Seamless Copper
Water Tube

B88M-05.....Standard Specification for Seamless Copper
Water Tube (Metric)

B280-08.....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-04.....Standard Specification for Filler Metals for
Brazing and Braze Welding

H. Federal Specifications (Fed. Spec.)

Fed. Spec. GG

I. Underwriters Laboratories (U.L.):

U.L.207-2009.....Standard for Refrigerant-Containing Components
and Accessories, Nonelectrical

U.L.429-99 (Rev.2006)...Standard for Electrically Operated Valves

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. For piping over 100 mm (4 inch) use A53 Black SML steel.

B. Water and Drain Piping: Copper water tube, ASTM B88, Type K 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. Steel fittings: ASTM wrought steel fittings.

a. Refrigerant piping - Welded Joints.

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3. Flanges and flanged fittings: ASME B16.24.
4. 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 closed holding coil.
 - d. Thermostatic Expansion Valves: Comply with ARI 750. Brass body with stainless-steel or non-corrosive non-ferrous 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. 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.
5. Strainers: Designed to permit removing screen without removing strainer from piping system, and provided with screens 80 to 100 mesh in liquid lines DN 25 (NPS 1) and smaller, 60 mesh in liquid lines larger than DN 25 (NPS 1), and 40 mesh in suction lines. Provide strainers in liquid line serving each thermostatic expansion

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valve, and in suction line serving each refrigerant compressor not equipped with integral strainer.

6. 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.
7. Refrigerant Filter-Dryers: UL listed, angle or in-line type, as shown on drawings. Conform to ARI Standard 730 and ASHRAE Standard 63.1. Heavy gage 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.
8. 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.
9. Water Piping Valves and Accessories: Refer to specification Section 23 21 13, HYDRONIC PIPING.

2.2 GAGES

- A. Temperature Gages: Comply with ASME B40.200. Industrial-duty type and in required temperature range for service in which installed. Gages 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 gages 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 gages shall be provided in thermal wells located 1525 to 2135 mm (5 to 7 feet) above the finished floor. Remote element type temperature gages shall be provided in thermal wells located 2135 mm (7 feet) above the finished floor.
- B. Vacuum and Pressure Gages: Comply with ASME B40.100 and provide with throttling type needle valve or a pulsation dampener and shut-off valve. Gage 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

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system working pressure. Each gage 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 (gage) (250 psig).
2. Discharge: 0 to 3445 kPa (gage) (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 and STEAM GENERATION.

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/cu.m (3 lb/cu.ft.) 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, PLUMBING, and BOILER PLANT INSULATION.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install refrigerant piping and refrigerant containing parts in accordance with ASHRAE Standard 15 and ASME B31.5
 1. Install piping as short as possible, with a minimum number of joints, elbow and fittings.

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2. Install piping with adequate clearance between pipe and adjacent walls and hangers to allow for service and inspection. Space piping, including insulation, to provide 25 mm (1 inch) minimum clearance between adjacent piping or other surface. Use pipe sleeves through walls, floors, and ceilings, sized to permit installation of pipes with full thickness insulation.
3. Locate and orient valves to permit proper operation and access for maintenance of packing, seat and disc. Generally locate valve stems in overhead piping in horizontal position. Provide a union adjacent to one end of all threaded end valves. Control valves usually require reducers to connect to pipe sizes shown on the drawing.
4. Use copper tubing in protective conduit when installed below ground.
5. Install hangers and supports per ASME B31.5 and the refrigerant piping manufacturer's recommendations.

B. Joint Construction:

1. Brazed Joints: Comply with AWS "Brazing Handbook" and with filler materials complying with AWS A5.8/A5.8M.
 - a. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper tubing.
 - b. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.
 - c. Swab fittings and valves with manufacturer's recommended cleaning fluid to remove oil and other compounds prior to installation.
 - d. Pass nitrogen gas through the pipe or tubing to prevent oxidation as each joint is brazed. Cap the system with a reusable plug after each brazing operation to retain the nitrogen and prevent entrance of air and moisture.

- C. Protect refrigerant system during construction against entrance of foreign matter, dirt and moisture; have open ends of piping and connections to compressors, condensers, evaporators and other equipment tightly capped until assembly.
- D. Pipe relief valve discharge to outdoors for systems containing more than 45 kg (100 lbs) of refrigerant.

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- 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.

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 more 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."

3.4 FIELD QUALITY CONTROL

Prior to initial operation examine and inspect piping system for conformance to plans and specifications and ASME B31.5. Correct equipment, material, or work rejected because of defects or nonconformance with plans and specifications, and ANSI codes for pressure piping.

- A. After completion of piping installation and prior to initial operation, conduct test on piping system according to ASME B31.5. Furnish materials and equipment required for tests. Perform tests in the presence of COR. If the test fails, correct defects and perform the test again until it is satisfactorily done and all joints are proved tight.

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1. Every refrigerant-containing parts of the system that is erected on the premises, except compressors, condensers, evaporators, safety devices, pressure gages, control mechanisms and systems that are factory tested, shall be tested and proved tight after complete installation, and before operation.
 2. The high and low side of each system shall be tested and proved tight at not less than the lower of the design pressure or the setting of the pressure-relief device protecting the high or low side of the system, respectively, except systems erected on the premises using non-toxic and non-flammable Group A1 refrigerants with copper tubing not exceeding DN 18 (NPS 5/8). This may be tested by means of the refrigerant charged into the system at the saturated vapor pressure of the refrigerant at 20 degrees C (68 degrees F) minimum.
- B. Test Medium: A suitable dry gas such as nitrogen 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 gage on the outlet side. The pressure relief device shall be set above the test pressure but low enough to prevent permanent deformation of the system components.

3.5 SYSTEM TEST AND CHARGING

- A. System Test and Charging: As recommended by the equipment manufacturer or as follows:
1. Connect a drum of refrigerant to charging connection and introduce enough refrigerant into system to raise the pressure to 70 kPa (10 psi) gage. Close valves and disconnect refrigerant drum. Test system for leaks with halide test torch or other approved method suitable for the test gas used. Repair all leaking joints and retest.
 2. Connect a drum of dry nitrogen to charging valve and bring test pressure to design pressure for low side and for high side. Test entire system again for leaks.
 3. Evacuate the entire refrigerant system by the triplicate evacuation method with a vacuum pump equipped with an electronic gage reading in mPa (microns). Pull the system down to 665 mPa (500 microns) 665

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mPa (2245.6 inches of mercury at 60 degrees F) and hold for four hours then break the vacuum with dry nitrogen (or refrigerant). Repeat the evacuation two more times breaking the third vacuum with the refrigeration to be charged and charge with the proper volume of refrigerant.

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SECTION 23 25 00

HVAC WATER TREATMENT

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies cleaning and treatment of circulating HVAC water systems, including the following.
 - 1. Cleaning compounds.
 - 2. Chemical treatment for closed loop heat transfer systems.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- D. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
- E. Section 23 21 13, HYDRONIC PIPING.
- F. Section 23 22 13, STEAM and CONDENSATE HEATING PIPING.

1.3 QUALITY ASSURANCE

- A. Refer to paragraph, QUALITY ASSURANCE in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Technical Services: Provide the services of an experienced water treatment chemical engineer or technical representative to direct flushing, cleaning, pre-treatment, training, debugging, and acceptance testing operations; direct and perform chemical limit control during construction period and monitor systems for a period of 12 months after acceptance, including not less than 6 service calls and written status reports. Emergency calls are not included. Minimum service during construction/start-up shall be 6 hours.
- C. Chemicals: Chemicals shall be non-toxic approved by local authorities and meeting applicable EPA requirements.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Manufacturer's Literature and Data including:
 - 1. Cleaning compounds and recommended procedures for their use.

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- 2. Chemical treatment for closed systems, including installation and operating instructions.
- C. Water analysis verification.
- D. Materials Safety Data Sheet for all proposed chemical compounds, based on U.S. Department of Labor Form No. L5B-005-4.
- E. Maintenance and operating instructions in accordance with Section 01 00 00, GENERAL REQUIREMENTS.

1.5 APPLICABLE PUBLICATIONS

- A. The publication listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. National Fire Protection Association (NFPA):
70-2014.....National Electric Code (NEC)
- C. American Society for Testing and Materials (ASTM):
F441/F441M-02 (2008). Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80

PART 2 - PRODUCTS

2.1 CLEANING COMPOUNDS

- A. Alkaline phosphate or non-phosphate detergent/surfactant/specific to remove organic soil, hydrocarbons, flux, pipe mill varnish, pipe compounds, iron oxide, and like deleterious substances, with or without inhibitor, suitable for system wetted metals without deleterious effects.
- B. All chemicals to be acceptable for discharge to sanitary sewer.
- C. Refer to Section 23 21 13, HYDRONIC PIPING and Section 23 22 13, STEAM and CONDENSATE HEATING PIPING, PART 3, for flushing and cleaning procedures.

2.2 CHEMICAL TREATMENT FOR CLOSED LOOP SYSTEMS

- A. Consult the COR to determine the exact compounds and concentrations required to match the existing chemical treatment systems.
- B. Inhibitor: Provide sodium nitrite/borate, molybdate-based inhibitor or other approved compound suitable for make-up quality and make-up rate and which will cause or enhance bacteria/corrosion problems or mechanical seal failure due to excessive total dissolved solids. Shot feed manually. Maintain inhibitor residual as determined by water

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- treatment laboratory, taking into consideration residual and temperature effect on pump mechanical seals.
- C. pH Control: Inhibitor formulation shall include adequate buffer to maintain pH range of 8.0 to 10.5.
 - D. Performance: Protect various wetted, coupled, materials of construction including ferrous, and red and yellow metals. Maintain system essentially free of scale, corrosion, and fouling. Corrosion rate of following metals shall not exceed specified mills per year penetration; ferrous, 0-2; brass, 0-1; copper, 0-1. Inhibitor shall be stable at equipment skin surface temperatures and bulk water temperatures of not less than 121 degrees C (250 degrees F) and 52 degrees C (125 degrees Fahrenheit) respectively. Heat exchanger fouling and capacity reduction shall not exceed that allowed by fouling factor 0.0005.
 - E. Pot Feeder: By-pass type, complete with necessary shut off valves, drain and air release valves, and system connections, for introducing chemicals into system, cast iron or steel tank with funnel or large opening on top for easy chemical addition. Feeders shall be 18.9 L (five gallon) minimum capacity at 860 kPa (125 psig) minimum working pressure.

2.3 EQUIPMENT AND MATERIALS IDENTIFICATION

- A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Delivery and Storage: Deliver all chemicals in manufacturer's sealed shipping containers. Store in designated space and protect from deleterious exposure and hazardous spills.
- B. Install equipment furnished by the chemical treatment supplier and charge systems according to the manufacturer's instructions and as directed by the Technical Representative.
- C. Consult the COR for current treatment of the closed loop piping system.
- D. Before adding cleaning chemical to the closed system, all air handling coils and fan coil units should be isolated by closing the inlet and outlet valves and opening the bypass valves. This is done to prevent dirt and solids from lodging the coils.

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- E. Do not valve in or operate system pumps until after system has been cleaned.
- F. After chemical cleaning is satisfactorily completed, open the inlet and outlet valves to each coil and close the by-pass valves. Also, clean all strainers.
- G. Perform tests and report results in accordance with Section 01 00 00, GENERAL REQUIREMENTS.
- H. After cleaning is complete, and water PH is acceptable to manufacturer of water treatment chemical, add manufacturer-recommended amount of chemicals to systems.
- I. Instruct VA personnel in system maintenance and operation in accordance with Section 01 00 00, GENERAL REQUIREMENTS.

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SECTION 23 31 00
HVAC DUCTS AND CASINGS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Ductwork and accessories for HVAC including the following:

1. Supply air, return air, outside air, exhaust, make-up air, and relief systems.

B. Definitions:

1. SMACNA Standards as used in this specification means the HVAC Duct Construction Standards, Metal and Flexible.
2. Seal or Sealing: Use of liquid or mastic sealant, with or without compatible tape overlay, or gasketing of flanged joints, to keep air leakage at duct joints, seams and connections to an acceptable minimum.
3. Duct Pressure Classification: SMACNA HVAC Duct Construction Standards, Metal and Flexible.
4. Exposed Duct: Exposed to view in a finished room, exposed to weather.

1.2 RELATED WORK

- A. Fire Stopping Material: Section 07 84 00, FIRESTOPPING.
- B. Outdoor and Exhaust Louvers: Section 08 90 00, LOUVERS and VENTS.
- C. General Mechanical Requirements: Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- D. Noise Level Requirements: Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.
- E. Duct Insulation: Section 23 07 11, HVAC, PLUMBING, and BOILER PLANT INSULATION
- F. Plumbing Connections: Section 22 11 00, FACILITY WATER DISTRIBUTION

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- G. Air Flow Control Valves and Terminal Units: Section 23 36 00, AIR TERMINAL UNITS.
- H. Duct Mounted Coils: Section 23 82 16, AIR COILS.
- I. Supply Air Fans: Section 23 73 43, CUSTOM, INDOOR CENTRAL-STATION AIR-HANDLING UNITS and Section 23 74 43, CUSTOM, OUTDOOR CENTRAL-STATION AIR-HANDLING UNITS.
- J. Return Air and Exhaust Air Fans: Section 23 34 00, HVAC FANS.
- K. Air Filters and Filters' Efficiencies: Section 23 40 00, HVAC AIR CLEANING DEVICES.
- L. Duct Mounted Instrumentation: Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
- M. Testing and Balancing of Air Flows: Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC.
- N. Smoke Detectors: Section 28 31 00, FIRE DETECTION and ALARM.

1.3 QUALITY ASSURANCE

- A. Refer to article, QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Fire Safety Code: Comply with NFPA 90A-15 and NFPA 92-15.
- C. Duct System Construction and Installation: Referenced SMACNA Standards are the minimum acceptable quality.
- D. Duct Sealing, Air Leakage Criteria, and Air Leakage Tests: Ducts shall be sealed as per duct sealing requirements of SMACNA HVAC Air Duct Leakage Test Manual for duct pressure classes shown on the drawings.
- E. Duct accessories exposed to the air stream, such as dampers of all types (except smoke dampers) and access openings, shall be of the same material as the duct or provide at least the same level of corrosion resistance.

1.4 SUBMITTALS

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

B. Manufacturer's Literature and Data:

1. Rectangular ducts:

- a. Schedules of duct systems, materials and selected SMACNA construction alternatives for joints, sealing, gage and reinforcement.
- b. Sealants and gaskets.
- c. Access doors.

2. Round and flat oval duct construction details:

- 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.

C. Coordination Drawings: Refer to article, SUBMITTALS, in Section 23 05 11 - Common Work Results for HVAC.

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1.5 APPLICABLE PUBLICATIONS

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

B. American Society of Civil Engineers (ASCE):

ASCE7-05.....Minimum Design Loads for Buildings and Other Structures

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

A167-99(2009).....Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip

A653-09.....Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy coated (Galvannealed) by the Hot-Dip process

A1011-09a.....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

B209-07.....Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate

C1071-05e1.....Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)

E84-09a.....Standard Test Method for Surface Burning Characteristics of Building Materials

D. National Fire Protection Association (NFPA):

90A-15.....Standard for the Installation of Air Conditioning and Ventilating Systems

92-15.....Standard for Smoke Control Systems

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

3rd Edition - 2005....HVAC Duct Construction Standards, Metal and Flexible

2nd Edition - 2012....HVAC Air Duct Leakage Test Manual

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7th Edition - 2003....Fibrous Glass Duct Construction Standards

F. Underwriters Laboratories, Inc. (UL):

181-08.....Factory-Made Air Ducts and Air Connectors

555-06Standard for Fire Dampers

555S-06Standard for Smoke Dampers

PART 2 - PRODUCTS

2.1 DUCT MATERIALS AND SEALANTS

- A. General: Except for systems specified otherwise, construct ducts, casings, and accessories of galvanized sheet steel, ASTM A653, coating G90; or, aluminum sheet, ASTM B209, alloy 1100, 3003 or 5052.
- B. Specified Corrosion Resistant Systems: Stainless steel sheet, ASTM A167, Class 302 or 304, Condition A (annealed) Finish No. 4 for exposed ducts and Finish No. 2B for concealed duct or ducts located in mechanical rooms.
- C. Joint Sealing: Refer to SMACNA HVAC Duct Construction Standards, paragraph S1.9.
 - 1. Sealant: Elastomeric compound, gun or brush grade, maximum 25 flame spread and 50 smoke developed (dry state) compounded specifically for sealing ductwork as recommended by the manufacturer. Generally provide liquid sealant, with or without compatible tape, for low clearance slip joints and heavy, permanently elastic, mastic type where clearances are larger. Oil base caulking and glazing compounds are not acceptable because they do not retain elasticity and bond.
 - 2. Tape: Use only tape specifically designated by the sealant manufacturer and apply only over wet sealant. Pressure sensitive tape shall not be used on bare metal or on dry sealant.
 - 3. Gaskets in Flanged Joints: Soft neoprene.
- D. Approved factory made joints may be used.

2.2 DUCT CONSTRUCTION AND INSTALLION

- A. Construct duct according to the following schedule:

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DUCT CONSTRUCTION SCHEDULE

AIR SYSTEM	DUCTWORK MATERIAL	PRESSURE CLASSIFICATION (IN W.G.)	MAX. ALLOW LEAK RATE (%)
Supply Air from Air Handling Units AC-20 and AC-19	Galvanized steel	+ 10 between air handling units and smoke dampers; +6 between smoke dampers and constant or variable air volume control boxes or valves; +2 down stream of constant or variable air volume control boxes or valves	3
Return Air from Air Handling Units AC-20, AC-19, and AC-18	Galvanized steel	-2 upstream of fan +2 downstream of fan	3
General Exhaust Systems EF-42 and EF-54	Galvanized steel	- 2 upstream of fan; +2 downstream of fan	3
Outside Air Intake Plenum for AC-20 and AC-19	Double-wall casing, 2" insulated, factory-fabricated	-4	3
Outside Air for AC-18 and AC-19	Galvanized steel	-2	5

B. Seal Class: All ductwork shall receive Class A Seal

C. Duct for Negative Pressure Up to 750 Pa (3 inch W.G.).

1. Round Duct: Galvanized steel, spiral lock seam construction with standard slip joints.

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2. Rectangular Duct: Galvanized steel, minimum 1.0 mm (20 gage), Pittsburgh lock seam, companion angle joints 32 mm by 3.2 mm (1-1/4 by 1/8 inch) minimum at not more than 2.4 m (8 feet) spacing. Approved pre-manufactured joints are acceptable in lieu of companion angles.
- D. Round and Flat Oval Ducts: Furnish duct and fittings made by the same manufacturer to insure good fit of slip joints. When submitted and approved in advance, round and flat oval duct, with size converted on the basis of equal pressure drop, may be furnished in lieu of rectangular duct design shown on the drawings.
1. Elbows: Diameters 80 through 200 mm (3 through 8 inches) shall be two sections die stamped, all others shall be gored construction, maximum 18 degree angle, with all seams continuously welded or standing seam. Coat galvanized areas of fittings damaged by welding with corrosion resistant aluminum paint or galvanized repair compound.
 2. Provide bell mouth, conical tees or taps, laterals, reducers, and other low loss fittings as shown in SMACNA HVAC Duct Construction Standards.
 3. Provide flat side reinforcement of oval ducts as recommended by the manufacturer and SMACNA HVAC Duct Construction Standard S3.13. Because of high pressure loss, do not use internal tie-rod reinforcement unless approved by the Contracting Officers Representative (COR).
- E. Casings and Plenums: Construct in accordance with SMACNA HVAC Duct Construction Standards Section 6, including curbs, access doors, pipe penetrations, eliminators and drain pans. Access doors shall be hollow metal, insulated, with latches and door pulls, 500 mm (20 inches) wide by 1200 - 1350 mm (48 - 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.

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F. Volume Dampers: Single blade or opposed blade, multi-louver type as detailed in SMACNA Standards. Refer to SMACNA Detail for Single Blade and for Multi-blade Volume Dampers.

G. Duct Hangers and Supports: Refer to SMACNA Standards Section IV. Avoid use of trapeze hangers for round duct.

2.3 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.

B. Openings shall be as large as feasible in small ducts, 300 mm by 300 mm (12 inch by 12 inch) minimum where possible. Access sections in insulated ducts shall be double-wall, insulated. Transparent shatterproof covers are preferred for uninsulated ducts.

1. For rectangular ducts: Refer to SMACNA HVAC Duct Construction Standards (Figure 2-12).
2. For round and flat oval duct: Refer to SMACNA HVAC duct Construction Standards (Figure 2-11).

2.4 FIRE DAMPERS

A. Galvanized steel, interlocking blade type, UL listing and label, 1-1/2 hour rating, 70 degrees C (160 degrees F) fusible line, 100 percent free opening with no part of the blade stack or damper frame in the air stream.

B. Fire dampers in wet air exhaust shall be of stainless steel construction, all others may be galvanized steel.

C. Minimum requirements for fire dampers:

1. The damper frame may be of design and length as to function as the mounting sleeve, thus eliminating the need for a separate sleeve, as

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allowed by UL 555. Otherwise provide sleeves and mounting angles, minimum 1.9 mm (14 gage), required to provide installation equivalent to the damper manufacturer's UL test installation.

2. Submit manufacturer's installation instructions conforming to UL rating test.

2.5 SMOKE DAMPERS

- A. Maximum air velocity, through free area of open damper, and pressure loss: Low pressure and medium pressure duct (supply, return, exhaust, outside air): 450 m/min (1500 fpm). Maximum static pressure loss: 32 Pa (0.13 inch W.G.).
- B. Maximum air leakage, closed damper: 0.32 cubic meters /min/square meter (4.0 CFM per square foot) at 750 Pa (3 inch W.G.) differential pressure.
- C. Minimum requirements for dampers:
 1. Shall comply with requirements of Table 6-1 of UL 555S, except for the Fire Endurance and Hose Stream Test.
 2. Frame: Galvanized steel channel with side, top and bottom stops or seals.
 3. Blades: Galvanized steel, parallel type preferably, 300 mm (12 inch) maximum width, edges sealed with neoprene, rubber or felt, if required to meet minimum leakage. Airfoil (streamlined) type for minimum noise generation and pressure drop are preferred for duct mounted dampers.
 4. Shafts: Galvanized steel.
 5. Bearings: Nylon, bronze sleeve or ball type.
 6. Hardware: Zinc plated.
 7. Operation: Automatic open/close. No smoke damper that requires manual reset or link replacement after actuation is acceptable. See drawings for required control operation.

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- D. Motor operator (actuator): Provide pneumatic or electric as required by the automatic control system, externally mounted on stand-offs to allow complete insulation coverage.

2.6 COMBINATION FIRE AND SMOKE DAMPERS

- A. Combination fire and smoke dampers: Multi-blade type units meeting all requirements of both fire dampers and smoke dampers shall be used where shown and may be used at the Contractor's option where applicable.

2.7 FIRE DOORS

- A. Galvanized steel, interlocking blade type, UL listing and label, 71 degrees C (160 degrees F) fusible link, 3 hour rating and approved for openings in Class A fire walls with rating up to 4 hours, 100 percent free opening with no part of the blade stack or damper frame in the air stream.

2.8 FLEXIBLE AIR DUCT

- A. General: Factory fabricated, complying with NFPA 90A for connectors not passing through floors of buildings. Flexible ducts shall not penetrate any fire or smoke barrier which is required to have a fire resistance rating of one hour or more. Flexible duct length shall not exceed 1.5 m (5 feet). Provide insulated acoustical air duct connectors in supply air duct systems and elsewhere as shown.
- B. Flexible ducts shall be listed by Underwriters Laboratories, Inc., complying with UL 181. Ducts larger than 200 mm (8 inches) in diameter shall be Class 1. Ducts 200 mm (8 inches) in diameter and smaller may be Class 1 or Class 2.
- C. Insulated Flexible Air Duct: Factory made including mineral fiber insulation with maximum C factor of 0.25 at 24 degrees C (75 degrees F) mean temperature, encased with a low permeability moisture barrier outer jacket, having a puncture resistance of not less than 50 Beach Units. Acoustic insertion loss shall not be less than 3 dB per 300 mm (foot) of straight duct, at 500 Hz, based on 150 mm (6 inch) duct, of 750 m/min (2500 fpm).
- D. Application Criteria:

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1. Temperature range: -18 to 93 degrees C (0 to 200 degrees F) internal.
2. Maximum working velocity: 1200 m/min (4000 feet per minute).
3. Minimum working pressure, inches of water gage: 2500 Pa (10 inches) positive, 500 Pa (2 inches) negative.

E. Duct Clamps: 100 percent nylon strap, 80 kg (175 pounds) minimum loop tensile strength manufactured for this purpose or stainless steel strap with cadmium plated worm gear tightening device. Apply clamps with sealant and as approved for UL 181, Class 1 installation.

2.9 FLEXIBLE DUCT CONNECTIONS

A. Where duct connections are made to fans, air terminal units, and air handling units, install a non-combustible flexible connection of 822 g (29 ounce) neoprene coated fiberglass fabric approximately 150 mm (6 inches) wide. For connections exposed to sun and weather provide hypalon coating in lieu of neoprene. Burning characteristics shall conform to NFPA 90A. Securely fasten flexible connections to round ducts with stainless steel or zinc-coated iron draw bands with worm gear fastener. For rectangular connections, crimp fabric to sheet metal and fasten sheet metal to ducts by screws 50 mm (2 inches) on center. Fabric shall not be stressed other than by air pressure. Allow at least 25 mm (one inch) slack to insure that no vibration is transmitted.

2.10 SOUND ATTENUATING UNITS

A. Casing, not less than 1.0 mm (20 gage) galvanized sheet steel, or 1.3 mm (18 gage) aluminum fitted with suitable flanges to make clean airtight connections to ductwork. Sound-absorbent material faced with glass fiber cloth and covered with not less than 0,6 mm (24 gage) or heavier galvanized perforated sheet steel, or 0.85 mm (22 gage) or heavier perforated aluminum. Perforations shall not exceed 4 mm (5/32-inch) diameter, approximately 25 percent free area. Sound absorbent material shall be long glass fiber acoustic blanket meeting requirements of NFPA 90A.

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- B. Entire unit shall be completely air tight and free of vibration and buckling at internal static pressures up to 2000 Pa (8 inches W.G.) at operating velocities.
- C. Pressure drop through each unit: Not to exceed indicated value at design air quantities indicated.
- D. Submit complete independent laboratory test data showing pressure drop and acoustical performance.
- E. Cap open ends of attenuators at factory with plastic, heavy duty paper, cardboard, or other appropriate material to prevent entrance of dirt, water, or any other foreign matter to inside of attenuator. Caps shall not be removed until attenuator is installed in duct system.

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: 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 (two inch) length for insulated duct, and a minimum 25 mm (one inch) length for duct not insulated. Test hole shall have a flat gasket for rectangular ducts and a concave gasket for round ducts at the base, and a screw cap to prevent air leakage.

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- B. Provide instrument test holes at each duct or casing mounted temperature sensor or transmitter, and at entering and leaving side of each heating coil, cooling coil, and heat recovery unit.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with provisions of Section 23 05 11, COMMON WORK RESULTS FOR HVAC, particularly regarding coordination with other trades and work in existing buildings.
- B. Fabricate and install ductwork and accessories in accordance with referenced SMACNA Standards:
 - 1. Drawings show the general layout of ductwork and accessories but do not show all required fittings and offsets that may be necessary to connect ducts to equipment, boxes, diffusers, grilles, etc., and to coordinate with other trades. Fabricate ductwork based on field measurements. Provide all necessary fittings and offsets at no additional cost to the government. Coordinate with other trades for space available and relative location of HVAC equipment and accessories on ceiling grid. Duct sizes on the drawings are inside dimensions which shall be altered by Contractor to other dimensions with the same air handling characteristics where necessary to avoid interferences and clearance difficulties.
 - 2. Provide duct transitions, offsets and connections to dampers, coils, and other equipment in accordance with SMACNA Standards, Section II. 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, Chapter 6. Design casing access doors to swing against air pressure so that pressure helps to maintain a tight seal.

- C. Install duct hangers and supports in accordance with SMACNA Standards, Chapter 4.
- D. Install fire dampers, smoke dampers and combination fire/smoke dampers in accordance with the manufacturer's instructions to conform to the installation used for the rating test. Install fire dampers, smoke dampers and combination fire/smoke dampers at locations indicated and where ducts penetrate fire rated and/or smoke rated walls, shafts and where required by the COR. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges per UL and NFPA. Demonstrate re-setting of fire dampers and operation of smoke dampers to the COR.
- E. Seal openings around duct penetrations of floors and fire rated partitions with fire stop material as required by NFPA 90A.
- F. Flexible duct installation: Refer to SMACNA Standards, Chapter 3. Ducts shall be continuous, single pieces not over 1.5 m (5 feet) long (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 hour. Support ducts SMACNA Standards.
- G. Where diffusers, registers and grilles cannot be installed to avoid seeing inside the duct, paint the inside of the duct with flat black paint to reduce visibility.
- H. Control Damper Installation:
 - 1. Provide necessary blank-off plates required to install dampers that are smaller than duct size. Provide necessary transitions required to install dampers larger than duct size.
 - 2. Assemble multiple sections dampers with required interconnecting linkage and extend required number of shafts through duct for external mounting of damper motors.

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3. Provide necessary sheet metal baffle plates to eliminate stratification and provide air volumes specified. Locate baffles by experimentation, and affix and seal permanently in place, only after stratification problem has been eliminated.
 4. Install all damper control/adjustment devices on stand-offs to allow complete coverage of insulation.
- I. Air Flow Measuring Devices (AFMD): Install units with minimum straight run distances, upstream and downstream as recommended by the manufacturer.
- J. Protection and Cleaning: Adequately protect equipment and materials against physical damage. Place equipment in first class operating condition, or return to source of supply for repair or replacement, as determined by COR. Protect equipment and ducts during construction against entry of foreign matter to the inside and clean both inside and outside before operation and painting. When new ducts are connected to existing ductwork, clean both new and existing ductwork by mopping and vacuum cleaning inside and outside before operation.

3.2 DUCT LEAKAGE TESTS AND REPAIR

- A. Ductwork leakage testing shall be performed by the Testing and Balancing Contractor directly contracted by the General Contractor and independent of the Sheet Metal Contractor.
- B. Ductwork leakage testing shall be performed for all new portions of the air distribution system (including all supply, return, exhaust and relief ductwork), section by section, including fans, coils and filter sections. Based upon satisfactory initial duct leakage test results, the scope of the testing may be reduced by the COR on ductwork constructed to the 500 Pa (2" WG) duct pressure classification. In no case shall the leakage testing of ductwork constructed above the 500 Pa (2" WG) duct pressure classification or ductwork located in shafts or other inaccessible areas be eliminated.
- C. Test procedure, apparatus and report shall conform to SMACNA Leakage Test Manual. The maximum leakage rate allowed is 4 percent of the design air flow rate.

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- D. All ductwork shall be leak tested first before enclosed in a shaft or covered in other inaccessible areas.
- E. All tests shall be performed in the presence of the COR and the Test and Balance agency. The Test and Balance agency shall measure and record duct leakage and report to the COR and identify leakage source with excessive leakage.
- F. If any portion of the duct system tested fails to meet the permissible leakage level, the Contractor shall rectify sealing of ductwork to bring it into compliance and shall retest it until acceptable leakage is demonstrated to the COR.
- G. All tests and necessary repairs shall be completed prior to insulation or concealment of ductwork.
- H. Make sure all openings used for testing flow and temperatures by TAB Contractor are sealed properly.

3.3 DUCTWORK EXPOSED TO WIND VELOCITY

- A. Provide additional support and bracing to all exposed ductwork installed on the roof or outside the building to withstand wind velocity of 145 km/h (90 mph).

3.4 TESTING, ADJUSTING AND BALANCING

- 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 and STEAM GENERATION

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SECTION 23 34 00

HVAC FANS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Fans for heating, ventilating and air conditioning.
- B. Product Definitions: AMCA Publication 99, Standard 1-66.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS.
- B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- D. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION EQUIPMENT.
- E. Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.
- F. Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC.
- G. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
- H. Section 23 73 43, INDOOR CENTRAL-STATION AIR-HANDLING UNITS.
- I. Section 23 74 43, OUTDOOR CENTRAL-STATION AIR-HANDLING UNITS.
- J. Section 23 82 16, AIR COILS.
- K. Section 26 29 11, MOTOR CONTROLLERS.

1.3 QUALITY ASSURANCE

- A. Refer to paragraph, QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Fans and power ventilators shall be listed in the current edition of AMCA 261, and shall bear the AMCA performance seal.
- C. Operating Limits for Centrifugal Fans: AMCA 99 (Class I, II, and III).
- D. Fans and power ventilators shall comply with the following standards:
 - 1. Testing and Rating: AMCA 210.
 - 2. Sound Rating: AMCA 300.
- E. Vibration Tolerance for Fans and Power Ventilators: Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.
- F. Performance Criteria:

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1. The fan schedule shall show the design air volume and static pressure. Select the fan motor HP by increasing the fan BHP by 10 percent to account for the drive losses and field conditions.
2. Select the fan operating point as follows:
 - a. Forward Curve and Axial Flow Fans: Right hand side of peak pressure point
 - b. Air Foil, Backward Inclined, or Tubular: At or near the peak static efficiency
- G. Safety Criteria: Provide manufacturer's standard screen on fan inlet and discharge where exposed to operating and maintenance personnel.
- H. Corrosion Protection:
 1. Except for fans in fume hood exhaust service, all steel shall be mill-galvanized, or phosphatized and coated with minimum two coats, corrosion resistant enamel paint. Manufacturers paint and paint system shall meet the minimum specifications of: ASTM D1735 water fog; ASTM B117 salt spray; ASTM D3359 adhesion; and ASTM G152 and G153 for carbon arc light apparatus for exposure of non-metallic material.
 2. Fans for general purpose fume hoods, or chemical hoods, and radioisotope hoods shall be constructed of materials compatible with the chemicals being transported in the air through the fan.
- I. Spark resistant construction: If flammable gas, vapor or combustible dust is present in concentrations above 20% of the Lower Explosive Limit (LEL), the fan construction shall be as recommended by AMCA's Classification for Spark Resistant Construction. Drive set shall be comprised of non-static belts for use in an explosive.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Manufacturers Literature and Data:
 1. Fan sections, motors and drives.
 2. Centrifugal fans, motors, drives, accessories and coatings.
 - a. In-line centrifugal fans.
 - b. Tubular Centrifugal Fans.
 - c. Industrial fans.

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- d. Utility fans and vent sets.
- 3. Prefabricated roof curbs.
- 4. Power roof and wall ventilators.
- 5. Centrifugal ceiling fans.
- C. Certified Sound power levels for each fan.
- D. Motor ratings types, electrical characteristics and accessories.
- E. Roof curbs.
- F. Belt guards.
- G. Maintenance and Operating manuals in accordance with Section 01 00 00, GENERAL REQUIREMENTS.
- H. Certified fan performance curves for each fan showing cubic feet per minute (CFM) versus static pressure, efficiency, and horsepower for design point of operation.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. Air Movement and Control Association International, Inc. (AMCA):
 - 99-86.....Standards Handbook
 - 210-06.....Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
 - 261-09.....Directory of Products Licensed to bear the AMCA Certified Ratings Seal - Published Annually
 - 300-08.....Reverberant Room Method for Sound Testing of Fans
- C. American Society for Testing and Materials (ASTM):
 - B117-07a.....Standard Practice for Operating Salt Spray (Fog) Apparatus
 - D1735-08.....Standard Practice for Testing Water Resistance of Coatings Using Water Fog Apparatus
 - D3359-08.....Standard Test Methods for Measuring Adhesion by Tape Test
 - G152-06.....Standard Practice for Operating Open Flame Carbon Arc Light Apparatus for Exposure of Non-Metallic Materials

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G153-04.....Standard Practice for Operating Enclosed Carbon
Arc Light Apparatus for Exposure of Non-Metallic Materials

- D. Underwriters Laboratories, Inc. (UL):
181-2005.....Factory Made Air Ducts and Air Connectors

1.6 EXTRA MATERIALS

- A. Provide one additional set of belts for all belt-driven fans.

PART 2 - PRODUCTS

2.1 FAN SECTION (CABINET FAN)

- A. Refer to specification Section 23 74 43, CUSTOM, OUTDOOR CENTRAL-
STATION AIR-HANDLING UNITS.

2.2 CENTRIFUGAL FANS

- A. Standards and Performance Criteria: Refer to Paragraph, QUALITY
ASSURANCE. Record factory vibration test results on the fan or furnish
to the Contractor.
- B. Fan arrangement, unless noted or approved otherwise:
1. DWDl fans: Arrangement 3.
 2. SWSl fans: Arrangement 1, 3, 9 or 10.
- C. Construction: Wheel diameters and outlet areas shall be in accordance
with AMCA standards.
1. Housing: Low carbon steel, arc welded throughout, braced and
supported by structural channel or angle iron to prevent vibration
or pulsation, flanged outlet, inlet fully streamlined. Provide
lifting clips, and casing drain. Provide manufacturer's standard
access door. Provide 12.5 mm (1/2 inches) wire mesh screens for fan
inlets without duct connections.
 2. Wheel: Steel plate with die formed blades welded or riveted in
place, factory balanced statically and dynamically.
 3. Shaft: Designed to operate at no more than 70 percent of the first
critical speed at the top of the speed range of the fans class.
 4. Bearings: Heavy duty ball or roller type sized to produce a B10 life
of not less than 50,000 hours, and an average fatigue life of
200,000 hours. Extend filled lubrication tubes for interior bearings
or ducted units to outside of housing.
 5. Belts: Oil resistant, non-sparking and non-static.

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6. Belt Drives: Factory installed with final alignment belt adjustment made after installation.
7. Motors and Fan Wheel Pulleys: Adjustable pitch for use with motors through 15HP, fixed pitch for use with motors larger than 15HP. Select pulleys so that pitch adjustment is at the middle of the adjustment range at fan design conditions.
8. Motor, adjustable motor base, drive and guard: Furnish from factory with fan. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC for specifications. Provide protective sheet metal enclosure for fans located outdoors.
9. Furnish variable speed fan motor controllers where shown on the drawings. Refer to Section, MOTOR CONTROLLERS. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC for controller/motor combination requirements.
- D. In-line Centrifugal Fans: In addition to the requirements of paragraphs A and 2.2.C3 thru 2.2.C9, 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.
- E. Tubular Centrifugal Fans: In addition to the requirements of paragraphs A and 2.2.C2 thru 2.2.C9 provide;
 1. Housings: Hot rolled steel, one-piece design, 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.
- F. Industrial Fans: Use where scheduled or in lieu of centrifugal fans for low volume high static service. Construction specifications paragraphs A and C for centrifugal fans shall apply. Provide material handling flat blade type fan wheel.
- G. Centrifugal Plenum Fans
 - a. General: Direct-driven unhoused centrifugal fans consisting of wheel, fan shaft, bearings, motor, drive assembly, and

support structure.

- b. Wheels: Single-width, single-inlet (SWSI) steel multi-blade, welded to shroud, with backplate and inlet backplate keyed to shaft, and spun wheel inlet shroud operating at close tolerance to deep spun inlet cone. Impeller shall be of rigid construction without the use of stiffening rings or tie rods. Blades shall be backward-curved airfoil (AF), or backward-curved flat-plate (BI), as indicated on drawings.
- c. Inlet Screens: Where not connected to ductwork, furnish OSHA type heavy wire mesh screens, mounted inside of shaft bearings.
- d. Protective Enclosure: Furnish expanded metal screen with heavy gauge steel frame to completely enclose the fan wheel and support structure.
- e. Air volume flow sensors.
 - 1) Provide inlet bell tapings and connecting pneumatic tubing to provide piezometer type flow sensing.
 - 2) Manifold sensor tubing to one point for connection to transmitter provided under Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
 - 3) Sensor shall provide flow measurement with accuracy of $\pm 5\%$ with a turndown ratio of 5 to 1 of full design fan airflow.
- H. Utility Fans, Vent Sets and Small Capacity Fans: Class 1 design, arc welded housing, spun intake cone. Applicable construction specification, paragraphs A and C, for centrifugal fans shall apply for wheel diameters 300 mm (12 inches) and larger. Requirement for AMCA seal is waived for wheel diameters less than 300 mm (12 inches) and housings may be cast iron.

2.3 POWER ROOF VENTILATOR

- A. Standards and Performance Criteria: Refer to Paragraph, QUALITY ASSURANCE.
- B. Type: Centrifugal fan, backward inclined blades. Provide down-blast or up-blast type as indicated.
- C. Construction: Steel or aluminum, completely weatherproof, for curb mounting, exhaust cowl or entire drive assembly readily removable for

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servicing, aluminum bird screen on discharge, UL approved safety disconnect switch, conduit for wiring, vibration isolators for wheel, motor and drive assembly. Provide self-acting back draft damper. Provide electric motor operated damper where indicated.

D. Motor and Drive: Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION. Bearings shall be pillow block ball type with a minimum L-50 life of 200,000 hours. Motor shall be located out of air stream.

E. Prefabricated Roof Curb: As specified in paragraph 2.3 of this section.

2.4 POWER WALL VENTILATOR

A. Standards and Performance Criteria: Refer to Paragraph, QUALITY ASSURANCE.

B. Type: Centrifugal fan, backward inclined blades.

Construction: Steel or aluminum, completely weatherproof, for wall mounting, exhaust cowl or entire drive assembly readily removable for servicing, aluminum bird screen on discharge, UL approved safety disconnect switch, conduit for wiring, vibration isolators for wheel, motor and drive assembly. Provide self-acting back draft damper.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install fan, motor and drive in accordance with manufacturer's instructions.
- B. Align fan and motor sheaves to allow belts to run true and straight.
- C. Bolt equipment to curbs with galvanized lag bolts.
- D. Install vibration control devices as shown on drawings and specified in Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.

3.2 PRE-OPERATION MAINTENANCE

- A. Lubricate bearings, pulleys, belts and other moving parts with manufacturer recommended lubricants.
- B. Rotate impeller by hand and check for shifting during shipment and check all bolts, collars, and other parts for tightness.
- C. Clean fan interiors to remove foreign material and construction dirt and dust.

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3.3 START-UP AND INSTRUCTIONS

- A. Verify operation of motor, drive system and fan wheel according to the drawings and specifications.
- B. Check vibration and correct as necessary for air balance work.
- C. After air balancing is complete and permanent sheaves are in place perform necessary field mechanical balancing to meet vibration tolerance in Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.

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SECTION 23 36 00

AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Air terminal units, air flow control valves.

1.2 RELATED WORK

- A. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- C. Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.
- D. Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC.
- E. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
- F. Section 23 31 00, HVAC DUCTS and CASINGS.
- G. Section 23 82 16, AIR COILS.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Manufacturer's Literature and Data:
 - 1. Air Terminal Units: Submit test data.
 - 2. Air flow control valves.
- C. Samples: Provide one typical air terminal unit for approval by the COR. This unit will be returned to the Contractor after all similar units have been shipped and deemed acceptable at the job site.
- D. Certificates:
 - 1. Compliance with paragraph, QUALITY ASSURANCE.
 - 2. Compliance with specified standards.
- E. Operation and Maintenance Manuals: Submit in accordance with paragraph, INSTRUCTIONS, in Section 01 00 00, GENERAL REQUIREMENTS.

1.5 APPLICABLE PUBLICATIONS

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

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- B. Air Conditioning and Refrigeration Institute (AHRI)/(ARI):
880-08.....Air Terminals Addendum to ARI 888-98
incorporated into standard posted 15th December 2002
- C. National Fire Protection Association (NFPA):
90A-15.....Standard for the Installation of Air
Conditioning and Ventilating Systems
- D. Underwriters Laboratories, Inc. (UL):
181-08.....Standard for Factory-Made Air Ducts and Air
Connectors
- E. American Society for Testing and Materials (ASTM):
665-06Standard Specification for Mineral-Fiber
Blanket Thermal Insulation for Light Frame Construction and
Manufactured Housing

1.6 GUARANTEE

- A. In accordance with the GENERAL CONDITIONS

PART 2 - PRODUCTS

2.1 GENERAL

- A. Coils:
 - 1. All Air-Handling Units: Provide aluminum fins and copper coils for all hot water reheat coils.
 - 2. Water Heating Coils:
 - a. ARI certified, continuous plate or spiral fin type, leak tested at 2070 kPa (300 PSI).
 - b. Capacity: As indicated, based on scheduled entering water temperature.
 - c. Headers: Copper or Brass.
 - d. Fins: Aluminum, maximum 315 fins per meter (8 fins per inch).
 - e. Tubes: Copper, arrange for counter-flow of heating water.
 - f. Water Flow Rate: Minimum 0.032 Liters/second (0.5 GPM).
 - g. Provide vent and drain connection at high and low point, respectively of each coil.
 - h. Coils shall be guaranteed to drain.
- B. Labeling: Control box shall be clearly marked with an identification label that lists such information as nominal CFM, maximum and minimum

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factory-set airflow limits, coil type and coil connection orientation, where applicable.

- C. Factory calibrate air terminal units to air flow rate indicated. All settings including maximum and minimum air flow shall be field adjustable.
- D. Dampers with internal air volume control: See section 23 31 00 HVAC DUCTS and CASINGS.
- E. Terminal Sound Attenuators: See Section 23 31 00 HVAC DUCTS and CASINGS.

2.2 AIR TERMINAL UNITS (BOXES)

- A. General: Factory built, pressure independent units, factory set-field adjustable air flow rate, suitable for single duct applications. Clearly show on each unit the unit number and factory set air volumes corresponding to the contract drawings. Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC work assumes factory set air volumes. Coordinate flow controller sequence and damper operation details with the drawings and Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC. All air terminal units shall be brand new products of the same manufacturer.
- B. Capacity and Performance: The Maximum Capacity of a single terminal unit shall not exceed 566 Liters/second (1,200 CFM).
- C. Sound Power Levels:
 - 1. Acoustic performance of the air terminal units shall be based on the design noise levels for the spaces stipulated in Section 23 05 41 (Noise and Vibration Control for HVAC Piping and Equipment). Equipment schedule shall show the sound power levels in all octave bands. Terminal sound attenuators shall be provided, as required, to meet the intent of the design.
- D. Casing: Unit casing shall be constructed of galvanized steel no lighter than 0.85 mm (22 Gauge). Provide hanger brackets for attachment of supports.
 - 1. Lining material: Suitable to provide required acoustic performance, thermal insulation and prevent sweating. Meet the requirements of NFPA 90A and comply with UL 181 for erosion as well as ASTM C 665 antimicrobial requirements. Insulation shall consist of 13 mm (1/2

IN) thick non-porous foil faced rigid fiberglass insulation of 4-lb/cu.ft, secured by full length galvanized steel z-strips which enclose and seal all edges. Tape and adhesives shall not be used. Materials shall be non-friable and with surfaces, including all edges, fully encapsulated and faced with perforated metal or coated so that the air stream will not detach material. No lining material is permitted in the boxes serving operating rooms and Cystoscopy rooms.

2. Access panels (or doors): Provide panels large enough for inspection, adjustment and maintenance without disconnecting ducts, and for cleaning heating coils attached to unit, even if there are no moving parts. Panels shall be insulated to same standards as the rest of the casing and shall be secured and gasketed airtight. It shall require no tool other than a screwdriver to remove.
 3. Total leakage from casing: Not to exceed 2 percent of the nominal capacity of the unit when subjected to a static pressure of 750 Pa (3 inch WG), with all outlets sealed shut and inlets fully open.
- E. Construct dampers and other internal devices of corrosion resisting materials which do not require lubrication or other periodic maintenance.
1. Damper Leakage: Not greater than 2 percent of maximum rated capacity, when closed against inlet static pressure of 1 kPa (4 inch WG).
- F. Provide multi-point velocity pressure sensors with external pressure taps.
1. Provide direct reading air flow rate table pasted to box.
- G. Provide static pressure tubes.

Externally powered DDC variable air volume controller and damper actuator to be furnished under Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC for factory mounting on air terminal units. The DDC controller shall be electrically actuated.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Work shall be installed as shown and according to the manufacturer's diagrams and recommendations.

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- B. Handle and install units in accordance with manufacturer's written instructions.
- C. Support units rigidly so they remain stationary at all times. 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.
- D. Locate air terminal units to provide a straight section of inlet duct for proper functioning of volume controls. See VA Standard Detail.

3.2 OPERATIONAL TEST

- A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

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**SECTION 23 37 00
AIR OUTLETS AND INLETS**

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Roof Curbs
- B. Air Outlets and Inlets: Diffusers, Registers, and Grilles.

1.2 RELATED WORK

- A. General Mechanical Requirements: Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Noise Level Requirements: Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
- C. Testing and Balancing of Air Flows: Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.

1.3 QUALITY ASSURANCE

- A. Refer to article, QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Fire Safety Code: Comply with NFPA 90A.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Manufacturer's Literature and Data:
 - 1. Roof curbs.
- C. Diffusers, registers, grilles and accessories.
- D. Coordination Drawings: Refer to article, SUBMITTALS, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. Air Diffusion Council Test Code:

PART 2 - PRODUCTS

2.1 EQUIPMENT SUPPORTS

- A. Refer to Section 21 05 11, COMMON WORK RESULTS FOR FIRE SUPPRESSION, Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING, and Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

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2.2 AIR OUTLETS AND INLETS

A. Materials:

1. Steel or aluminum. Use aluminum air outlets and inlets for facilities located in high-humidity areas. Provide manufacturer's standard gasket.
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 Diffusion Council Code 1062GRD. Refer to Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT for NC criteria.

C. Air Supply Outlets:

1. Ceiling Diffusers: Suitable for surface mounting, exposed T-bar or special tile ceilings, off-white finish, square or round neck connection as shown on the drawings. Provide plaster frame for units in plaster ceilings.
 - a. Square, louver, fully adjustable pattern: Round neck, surface mounting unless shown otherwise on the drawings. Provide equalizing or control grid and volume control damper.
 - b. Louver face type: Square or rectangular, removable core for 1, 2, 3, or 4 way directional pattern. Provide equalizing or control grid and opposed blade damper.

Perforated face type: Manual adjustment for one-, two-, three-, or four-way horizontal air distribution pattern without change of air volume or pressure. Provide equalizing or control grid and opposed blade over overlapping blade damper. Perforated face diffusers for VAV systems shall have the pattern controller on the inner face, rather than in the neck and designed to discharge air horizontally at the ceiling maintaining a Coanda effect.

2. Supply Registers: Double deflection type with horizontal face bars and opposed blade damper with removable key operator.
 - a. Margin: Flat, 30 mm (1-1/4 inches) wide.
 - b. Bar spacing: 20 mm (3/4 inch) maximum.

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- c. Finish: Off white baked enamel for ceiling mounted units. Wall units shall have a prime coat for field painting, or shall be extruded with manufacturer's standard finish.
- 3. Supply Grilles: Same as registers but without the opposed blade damper.
- D. Return and Exhaust Registers and Grilles: Provide opposed blade damper without removable key operator for registers.
 - 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.
 - 2. Standard Type: Fixed horizontal face bars set at 30 to 45 degrees, approximately 30 mm (1-1/4 inch) margin.
 - 3. Perforated Face Type: To match supply units.
 - 4. Grid Core Type: 13 mm by 13 mm (1/2 inch by 1/2 inch) core with 30 mm (1-1/4 inch) margin.
 - 5. Door Grilles: Are furnished with the doors.
 - 6. Egg Crate Grilles: Aluminum or Painted Steel 1/2 by 1/2 by 1/2 inch grid providing 90% free area.
 - a. Heavy extruded aluminum frame shall have countersunk screw mounting. Unless otherwise indicated, register blades and frame shall have factory applied white finish.
 - b. Grille shall be suitable for duct or surface mounting as indicated on drawings. All necessary appurtenances shall be provided to allow for mounting.
- E. Acoustic Transfer Grille: Aluminum, suitable for partition or wall mounting.

2.3 WIRE MESH GRILLE

- A. Fabricate grille with 2 x 2 mesh 13 mm (1/2 inch) galvanized steel or aluminum hardware cloth in a spot welded galvanized steel frame with approximately 40 mm (1-1/2 inch) margin.
- B. Use grilles where shown in unfinished areas such as mechanical rooms.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with provisions of Section 23 05 11, COMMON WORK RESULTS FOR HVAC, particularly regarding coordination with other trades and work in existing buildings.

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- B. Protection and Cleaning: Protect equipment and materials against physical damage. Place equipment in first class operating condition, or return to source of supply for repair or replacement, as determined by Contracting Officers Representative (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 TESTING, ADJUSTING AND BALANCING (TAB)

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

3.3 OPERATING AND PERFORMANCE TESTS

- B. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION

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SECTION 23 40 00

HVAC AIR CLEANING DEVICES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Air filters for heating, ventilating and air conditioning.
- B. Definitions: Refer to ASHRAE Standard 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 Standard 52.2 Appendix J for definition of MERV-A.

1.2 RELATED WORK

- A. Section 23 05 11, COMMON WORK RESULTS FOR HVAC: General mechanical requirements and items, which are common to more than one section of Division 23.
- B. Section 23 73 43, CUSTOM, INDOOR CENTRAL-STATION AIR-HANDLING UNITS: Filter housing and racks.
- C. Section 23 74 43, CUSTOM, OUTDOOR CENTRAL-STATION AIR-HANDLING UNITS: Filter housing and racks.
- D. Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS: Requirements for commissioning, systems readiness checklists, and training.

1.3 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 Standard 52.2 for type filter under test and acceptable to Contracting Officers Representative (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 Appendix J. All testing is to be conducted on filters with a nominal 24 inch by 24 inch face dimension. Test for 150 m/min (500 fpm) will be accepted for lower velocity rated filters provided the test report of an

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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 Standard 52.2 report throughout the time the filter is in service. Within the first 6-12 weeks of service a filter may be pulled out of service and sent to an independent laboratory for ASHRAE Standard 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 cost to the Government.
- C. Comply with UL Standard 900 for flame test.
- D. Nameplates: Each filter shall bear a label or name plate indicating manufacturer's name, filter size, rated efficiency, and UL classification.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. Manufacturer's Literature and Data:

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1. Extended surface filters.
2. Holding frames. Identify locations.
3. Side access housings. Identify locations, verify insulated doors.
4. HEPA filters.
5. Magnehelic gages.
- C. Air Filter performance reports.
- D. Suppliers warranty.
- E. Field test results for HEPA filters as per paragraph 2.3.E.3.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by basic designation only.
- B. American Society of Heating, Refrigerating and Air-conditioning Engineers, Inc. (ASHRAE):
52.2-2007.....Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size, including Appendix J
- C. American Society of Mechanical Engineers (ASME):
NQA-1-2008.....Quality Assurance Requirements for Nuclear Facilities Applications
- D. Underwriters Laboratories, Inc. (UL):
900; Revision 15 July 2009 Test Performance of Air Filter Units

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

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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 Standard 900.

C. HVAC Filter Types

HVAC Filter Types Table 2.2C				
MERV Value ASHRAE 52.2	MERV-A Value ASHRAE 62.2 Appendix J	Application	Particle Size	Thickness /Type
8	8-A	Pre-Filter	3 to 10 Microns	50 mm (2-inch) Throwaway
11	11-A	After-Filter	1 to 3 Microns	150 mm (6-inch) or 300 mm (12-inch) Rigid Cartridge
13	13-A	After-Filter	0.3 to 1 Microns	150 mm (6-inch) or 300 mm (12-inch) Rigid Cartridge
14	14-A	Final-Filter	0.3 to 1 Microns	150 mm (6-inch) or 300 mm (12-inch) Rigid Cartridge

2.3 MEDIUM EFFICIENCY PLEATED PANEL PRE-FILTERS (2"; MERV 8; UL 900 CLASS 2):

A. Construction: Air filters shall be medium efficiency ASHRAE pleated panels consisting of cotton and synthetic or 100% 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.

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- B. Performance: The filter shall have a Minimum Efficiency Reporting Value of MERV 8 when evaluated under the guidelines of ASHRAE Standard 52.2. It shall also have a MERV-A of 8 when tested per Appendix J of the same standard. The media shall maintain or increase in efficiency over the life of the filter. Pertinent tolerances specified in Section 7.4 of the Air-Conditioning and Refrigeration Institute (ARI) Standard 850-93 shall apply to the performance ratings. All testing is to be conducted on filters with a nominal 24" x 24" face dimension.

Minimum Efficiency Reporting (MERV)	8
Dust Holding Capacity (Grams)	105
Nominal Size (Width x Height x Depth)	24x24x2
Rated Air Flow Capacity (Cubic Feet per Minute)	2,000
Rated Air Flow Rate (Feet per Minute)	500
Final Resistance (Inches w.g.)	1.0
Maximum Recommended Change-Out Resistance (Inches w.g.)	0.66
Rated Initial Resistance (Inches w.g.)	0.33

- C. The filters shall be approved and listed by Underwriters' Laboratories, Inc. as Class 2 when tested according to U. L. Standard 900 and CAN 4-5111.

2.4 HIGH EFFICIENCY EXTENDED SURFACE (INTERMEDIATE/AFTER (FINAL)) CARTRIDGE FILTERS (12"; 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 80 degrees C (176 degrees F). The filters must 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

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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 52.2-1999 test method. Where applicable, performance tolerance specified in Section 7.4 of the Air-Conditioning and Refrigeration Institute (ARI) Standard 850-93 shall apply to the performance ratings. All testing is to be conducted on filters with a nominal 24"x24" header dimension.

Minimum Efficiency Reporting Value (MERV)	14	13	11
Gross Media Area (Sq. Ft.)	197	197	197
Dust Holding Capacity (Grams)	486	430	465
Nominal Size (Width x Height x Depth)	24x24x12	24x24x12	24x24x12
Rated Air Flow Capacity (cubic feet per minute)	2,000	2,000	2,000
Rated Air Flow Rate (feet per minute)	500	500	500
Final Resistance (inches w.g.)	2.0	2.0	2.0
Maximum Recommended Change-Out Resistance (Inches w.g.)	0.74	0.68	0.54
Rated Initial Resistance (inches w.g.)	0.37	0.34	0.27

2.5 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. In-line housing depth shall not exceed 21". 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. Where installed

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outdoors, the housing shall be weatherproof and suitable for rooftop/outdoor installation. 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" deep prefilter, a 6" or 12" 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 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% at 3.0" w.g. Leakage in to or out of the housing shall be less than one half of 1% at 3.0" w.g. Accuracy of pneumatic pressure fitting, when to evaluate a single-stage, or multiple filter stages, shall be accurate within $\pm 3\%$ at 0.6" w.g.
4. Manufacturer shall provide evidence of facility certification to ISO 9001:2000.

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. In-line housing depth shall not exceed 25". 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" 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" 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" 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 9001:2008.

2.6 Instrumentation

- A. Magnehelic Differential Pressure Filter Gages: Nominal 100 mm (four inch) diameter, zero to 500 Pa (zero to two inch water gage), three 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 Specification 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.

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2.7 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 not permitted.
- C. Automatic Roll Type filters are not permitted.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install supports, filters and gages in accordance with manufacturer's instructions.
- B. Label clearly with words "Contaminated Air" on exhaust ducts leading to the HEPA filter housing.

3.2 START-UP AND TEMPORARY USE

- 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.

3.3 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.
- B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

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SECTION 23 72 00
AIR-TO-AIR ENERGY RECOVERY EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This Section specifies rotary air-to-air heat exchangers.

1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS: Requirements for pre-test of equipment.
- B. Section 23 05 11, COMMON WORK RESULTS FOR HVAC: General mechanical requirements and items, which are common to more than one section of Division 23.
- C. Section 23 21 23, HYDRONIC PUMPS: Requirements for pumping equipment.
- D. Section 23 07 11, HVAC and BOILER PLANT INSULATION: Requirements for piping insulation.
- E. Section 23 21 13, HYDRONIC PIPING: Requirements for piping for expansion tanks.
- F. Section 23 82 16, AIR COILS: Requirements for run-around system coils.
- G. Section 23 31 00, HVAC DUCTS and CASINGS: Requirements for sheet metal ducts and fittings.
- H. Section 23 40 00, HVAC AIR CLEANING DEVICES: Requirements for filters used before heat recovery coils.
- I. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC: Requirements for controls and instrumentation.
- J. Section 23 05 93, TESTING, ADJUSTING and BALANCING FOR HVAC: Requirements for testing, adjusting and balancing of HVAC system.
- K. Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS: Requirements for commissioning, systems readiness checklists, and training.
- L. Section 01 91 00 - GENERAL COMMISSIONING REQUIREMENTS

1.3 QUALITY ASSURANCE

- A. Refer to paragraph, GUARANTEE in specification Section 00 72 00, GENERAL CONDITIONS.
- B. Refer to specification Section 01 00 00, GENERAL REQUIREMENTS for performance tests and instructions to VA personnel.

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- C. Refer to paragraph QUALITY ASSURANCE in specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- D. 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.
- E. Performance Test: In accordance with PART 3.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Manufacturer's Literature and Data:
 - 1. Heat Pipe Heat Exchanger
 - 2. Rotary Heat Exchanger
 - 3. Plate Heat Exchanger
 - 4. Run-Around Energy Recovery System
- C. Certificate: Submit, simultaneously with shop drawings, an evidence of satisfactory service of the equipment on three similar installations.
- D. Submit type, size, arrangement and performance details. Present application ratings in the form of tables, charts or curves.
- E. Provide installation, operating and maintenance instructions, in accordance with Article, INSTRUCTIONS, in Section 01 00 00, GENERAL REQUIREMENTS.
- F. Completed System Readiness Checklists provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 23 08 00 COMMISSIONING OF HVAC SYSTEMS.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. Air Conditioning, Heating, and Refrigeration Institute (AHRI)
AHRI 1060-2005.....Performance Rating of Air-to-Air Heat
Exchangers for Energy Recovery Ventilation
Equipment
- C. American Society of Heating, Refrigeration and Air Conditioning
Engineers (ASHRAE):

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- 15-10.....Safety Standard for Refrigeration Systems
(ANSI)
- 52.1-92.....Gravimetric and Dust-Spot Procedures for
Testing Air-Cleaning Devices Used in General
Ventilation for Removing Particulate Matter
- 52.2-07.....Method of Testing General Ventilation Air-
Cleaning Devices for Removal Efficiency by
Particle Size
- 84-08.....Method of Testing Air-to-Air Heat/Energy
Exchangers
- D. American Society for Testing and materials (ASTM)
 - D635-10.....Standard Test Method for Rate of Burning and/or
Extent and Time of Burning of Plastics in a
Horizontal Position
 - E84-10.....Standard Test Method for Surface Burning
Characteristics of Building Materials
- E. American Society of Civil Engineers (ASCE)
 - ASCE 7-10.....Minimum Design Loads for Buildings and Other
Structures
- F. Underwriters Laboratories, Inc (UL)
 - 1812-2009.....Standard for Ducted Heat Recovery Ventilators
 - 1815-2009.....Standard for Nonducted Heat Recovery
Ventilators

PART 2 - PRODUCTS

2.1 ROTARY AIR-TO-AIR HEAT EXCHANGER:

- A. Exchanger Rotor or Wheel: Aluminum transfer media with a flame spread rating of 25 and less and smoke developed rating of 50 and less, and independently tested in accordance with ASTM standard E-84. Rotor media shall be independently tested in accordance with ASHRAE Standard 84. It shall allow laminar flow (but not radial) when operating within published operating airflow ranges and prevent leakage, bypassing and cross contamination by cross flow within wheel. Size the transfer media to allow passage of 800 micrometers particles without fouling or clogging. When latent heat transfer is required, treat media with non-degrading silica-gel desiccant coating that is bacteriostatic,

non-corroding and non-toxic. No asbestos material will be allowed. Wheel shall not condense water directly or require a condensate drain for summer or winter operation. Performance rating shall be in accordance with AHRI Standard 1060.

- B. Rotor: Polymer segmented wheel strengthened with radial spokes impregnated with non-migrating, water-selected, 3A molecular-sieve desiccant coating.
 - 1. Maximum Solid Size for media to pass: 800 micrometers.
- C. Casings shall be sealed on periphery of rotor as well as on duct divider and purge section. Seals shall be adjustable, of extended life materials and effective in limiting air leakage.
- D. Wheel shall be supported by ball or roller bearings and belt driven by a fractional horsepower, totally enclosed, NEMA Standard motor through a close coupled positively lubricated speed reducer, or gear/chain speed reduction. Refer to Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION EQUIPMENT.
 - 1. Motors for constant speed exchanger wheels shall be an AC motor.
 - 2. Variable-speed exchanger wheels shall have exchanger wheel speed and leaving-air temperature controlled by means of a variable-speed motor controller. The speed shall be controlled as noted in paragraph G below. Automatic changeover for summer-winter operations shall be controlled by an adjustable thermostatswitch. Set point of adjustable proportioning temperature controller and thermostatswitch shall be indicated on visible scale. System shall be capable of speed reduction down to 5 percent of capacity while maintaining adequate torque at any point of operation to rotate wheel.
- E. An automatic, factory-fabricated, field-adjustable purge unit shall limit exhaust air carry-over to less than 1.0 percent of rated volume. Purge shall be effective when static pressure difference between supply and exhaust is 125 Pa (one-half, inch wg) or greater, and it shall have provision for restriction or adjustment to limit purge air volume to not over five percent of rated air flow when a static pressure difference up to 2.5 kPa (10 inch wg) exists.
- F. Unit shall be constructed of heavy gage steel to insure rigidity and stability. Casing side panels shall be removable to insure easy access

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to internal parts and have integral flanges for flanged duct connection and lifting holes or lugs.

- G. Controls starting relay shall be factory mounted and wired, and include a manual motor starter for field wiring. Variable frequency controller shall be factory mounted and wired, permitting input of field connected 4-20 mA or 1-10-V control signal. Variable frequency controller shall be factory mounted and wired, with return- and outdoor-air sensors, automatic changeover thermostat and set-point adjuster, to vary rotor speed and maintain air differential temperature above set point. When exhaust-air temperature is less than outdoor-air temperature, the rotor shall be at maximum speed.

1. Pilot-Light Indicator: Display rotor rotation and speed. Speed Settings: Adjustable settings for maximum and minimum rotor speed limits.

- H. Filters: MERV 7, 2-inch throw-away type. Refer to Section 23 40 00 HVAC Air Cleaning Devices.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Follow the equipment manufacturer's instructions for handling and installation, and setting up of ductwork for makeup and exhaust air steamers for maximum efficiency.
- B. Rotary Air-to-Air Exchanger: Adjust seals and purge as recommended by the manufacturer. Verify correct installation of controls.
- 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.
- E. Brace heat recovery equipment installed in projects in Seismic area.

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.

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- 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 Senior Contracting Officers Representative (COR) in accordance with specification Section 01 00 00, GENERAL REQUIREMENTS.

3.3 INSTRUCTIONS

- A. Provide services of manufacturer's technical representative for four hours to instruct VA personnel in operation and maintenance of heat recovery equipment.

3.4 STARTUP AND TESTING

- A. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the COR and Commissioning Agent. Provide a minimum of 7 days prior notice.

3.5 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.
- B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

3.6 DEMONSTRATION AND TRAINING

- A. Provide services of manufacturer's technical representative for four hours to instruct VA personnel in operation and maintenance of units.
- B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS.

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SECTION 23 73 43

CUSTOM, INDOOR, CENTRAL-STATION AIR-HANDLING UNIT

PART 1 - GENERAL

1.1 SUMMARY

- A. This Specification defines engineering, design, materials of construction, fabrication, and performance requirements for a CUSTOM, INDOOR, CENTRAL-STATION AIR-HANDLING UNIT.
- B. The Unit manufacturer must receive and review the complete project bid document package. All drawings and specifications shall be made available to the manufacturer for the purposes of bidding and developing the proposal and submittal documents required herein. The manufacturer is responsible to request this information should the general contractor(s) and/or VAMC not provide in accordance with these requirements to deliver a complete package to the Unit manufacturer.
- C. Definitions: Custom Indoor Central Station Air-Handling Unit (CICSAHU): A factory fabricated assembly consisting of a custom central station air-handling unit, of supply fans, heating/cooling coils, filters, humidifiers, field installed DDC controls system, single point power connection and other necessary equipment/components to perform one or more of the following functions of circulating, filtering/cleaning, heating, cooling, humidifying, dehumidifying, and mixing of air to deliver and return/relieve/smoke purge/evac from the existing spaces served by the current unit. The new unit is a piece of equipment designed to be fully powered and controlled and to be factory fabricated and tested prior to shipment to project site. Design capacities of units shall be as scheduled on the drawings.

1.2 RELATED WORK

- A. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS: Coordination of Factory acceptance/site acceptance testing with project start-up/controls validation and overall commissioning efforts.
- B. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS: Requirements for commissioning, systems readiness checklists, and VAMC training.
- C. Section 07 84 00, FIRESTOPPING.

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- D. Section 23 05 11, COMMON WORK RESULTS FOR HVAC: General mechanical requirements and items, which are common to more than one section of Division 23.
- E. Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT: Sound and vibration requirements.
- F. Section 23 07 11, HVAC INSULATION: Piping and duct insulation.
- G. Section 23 21 13, HYDRONIC PIPING and Section 23 22 13, STEAM and CONDENSATE HEATING PIPING: Heating Hot Water (Reheat), Chilled Water, Cooling Coil Condensate, and Steam/Steam Condensate Heating, Cooling and Humidification Piping, Valves and Specialties.
- H. Section 23 82 16, AIR COILS: Heating, and cooling coils.
- I. Section 23 34 00, HVAC FANS: Return/relief and exhaust fans.
- J. Section 23 31 00, HVAC DUCTS and CASINGS: Requirements for galvanized steel ductwork, stainless steel ductwork, sealants, fire rated flexible duct connectors, fire dampers, smoke dampers, duct access doors and equipment supports.
- K. Section 23 40 00, HVAC AIR CLEANING DEVICES: Air filters and filters' efficiency.
- L. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC: HVAC controls.
- M. Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC: Testing, adjusting and balancing of air handling equipment, and Hydronic Pumps for air and water flows.
- N. Section 23 25 00, HVAC WATER TREATMENT: Chemical treatment for closed loop Hydronic systems.
- O. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC: Motor types.
- P. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- Q. Section 26 05 19, LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES.
- R. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.
- S. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS.
- T. Section 26 24 16, PANELBOARDS.
- U. Section 26 27 26, WIRING DEVICES.
- V. Section 26 29 11, MOTOR CONTROLLERS: Types of motor starters, variable speed/variable frequency drives.
- W. Section 26 29 21, ENCLOSED SWITCHES AND CIRCUIT BREAKERS.

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- X. Section 28 31 00, FIRE DETECTION AND ALARM: AHU Isolation Smoke Damper Smoke Detectors and associated wiring.

1.3 QUALITY ASSURANCE

- A. Refer to Article, Quality Assurance, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Equipment shall conform to requirements of national, state and local regulating authorities and be furnished in accordance with current applicable sections of following codes and standards: AMCA, ASHRAE, IBC, IMC, SMACNA, ASME, NEC, NFPA, OSHA, UL, ARI, ANSI, NEMA and ASTM. In event of discrepancies between this Specification and codes or standards, manufacturer shall notify Owner's Representative.
- C. All products and composite package shall meet all applicable paragraphs of IEEE, NEC and NEMA Standards, shall be designed for installation in accordance with NEC, and shall be UL or ETL labeled.
- D. Equipment and material shall be new and of first quality and workmanship, free from defects and suitable for the specified use.
- E. Certifications: Manufacturer shall certify in writing compliance with Purchase Order documents, warranties provided, and manufacturer's field service and demonstration requirements specified.
- F. Air Handling Units Certification
1. Air Handling Units with Housed Centrifugal Fans: The air handling units shall be certified in accordance with AHRI 430 and tested/rated in accordance with AHRI 260.
 2. 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.
- G. Heating, Cooling, and Air Handling Capacity and Performance Standards: AHRI 430, AHRI 410, ASHRAE 51, and AMCA 210.
- H. Performance Criteria:
1. The fan BHP shall include all system effects for all fans and v-belt drive losses for housed centrifugal fans.

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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.
- I. 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.
- J. Air Handling Unit and all associated internal components and appurtenances shall be tested and verified as a single piece of coordinated mechanical equipment. Documentation of factory acceptance testing/verification for the overall unit shall be submitted to VAMC COR prior to shipment from factory to project site.
- K. Provide an additional in field inspection and verification of the entire unit as a single piece of equipment after complete assembly at the job site. Field inspection is to be inclusive of all equipment in the unit and to including the structure. Non Corrosive nameplate is to be permanently attached to the unit at the entrance showing the date of the field inspection/approval of the operational AHU.

1.4 SUBMITTALS

- A. The contractor shall, in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES, furnish a complete submission for all Custom Outdoor Central Station Air Handling Units covered in the project. The submission shall include all information listed below. Partial and incomplete submissions shall be rejected without reviews.
- B. Proposal Requirements.
- The vendor shall submit the following data, drawings and information with the proposal:
1. List of exceptions to specifications, drawing schedules, AHU diagram drawing and all associated details on line-by-line basis.

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Include proposed materials, methods and cost difference where substitutions are allowed.

2. Completed Data sheets (see attachments). For fans, include curves with plots showing duty points at specified maximum and minimum operating conditions, efficiency and brake horsepower.
3. Representative outline or general arrangement drawings including overall dimensions and dimensions of field installed or assembled components.
4. System schematic drawings showing all components, instruments and control systems to be furnished with unit.
5. List of proposed manufacturers of fans, filters, coils, motors, drives, dampers, and other components within the AHU. Clearly note differences from scheduled basis of design manufacturers, noting equivalency as per submittal requirements.
6. Information on guarantees and warranties specified and on those available.
7. Recommended spare parts quotation for one (1) year operation.
8. Recommendation as to quantity of vendor supervision necessary for erection, commissioning and training with the estimated cost of services.
9. Calculations indicating that insulation thickness and thermal break will prevent condensation at design operating conditions.
10. Number of sections, and shipping, erection and operating weight of each section. Include dimensions and shipping weight of largest section of assembly that will ship as one piece.
11. Submit confirmation of design and coordination of pre-fabricated, insulated, equipment curb/rails to align with all shipping splits/base-rail support locations for mounting on new structural dunnage.
12. Overall power requirements and electrical data including V/PH/HZ for equipment/components that consume electrical power. Data for motors should also include HP, type, power factor and guaranteed minimum efficiency.

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13. Schedule (indicated in weeks) for submittal of drawings for approval, start and finish of Factory Acceptance Testing (FAT) and shipment of units after receipt of approved drawings.

C. After Award Requirements

Upon receipt of Purchase Order, prepare and submit shop drawings and product data prepared specifically for equipment being furnished, for use in fabrication and installation. Submittals shall show sufficient data to establish evidence of compliance with Purchase Order documents. After receipt of Purchase Order submit the following information:

1. Shop Drawings:

- a. Unit: Shop drawings showing all components, dimensions, weights, materials, gauges, finishes and module breaks. Include piping and electrical wiring and control diagrams. Indicate service corridors, access doors, access panels and service clearances around equipment for normal servicing. Include fabrication and installation details. Provide sections and elevations to indicate AHU utility connections, piping and power drops, etc. Include layout of electrical components such panel boards, transformers, disconnect switches, motors, variable frequency drives, light switches and fixtures. Indicate layout of major control components and required clearances for maintenance. Include coordinated anchoring information, and other information required for coordination.
- b. Fans: Show fan layout, housing, materials, gauges, dimensions, weights, vibration isolation bases and installation details.
- c. Provide shipping weights of major components such as fans and coils which may require removal/replacement. Include weights of removable/replaceable panels.

2. Manufacturer's Literature and Data:

- a. General: Submittals shall include fans, drives, motors, coils, humidifiers, plenum mixing outside/return/relief air/smoke dampers, smoke detectors, filter housings, UV

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lights, and all other related accessories/appurtenances. The contractor shall provide custom drawings showing total air handling unit assembly including dimensions, operating weight, access sections, flexible connections, vibration isolation, door swings, electrical disconnects, power transformers, lights, switches, wiring, utility connection points, unit support system, motor removal rail systems, drain pans, airflow and static pressure drops through each component (filters, coils, etc.), shipping splits and rigging points per section. Refer to drawings, controls diagrams, schedules and detail sheets for additional requirements.

- b. Fans: Manufacturer's fan performance (data includes cfm, rpm, bhp, motor nameplate data, tip speed, outlet velocity, true critical speeds and static pressure) and sound performance (data includes sound power level ratings by octave bands) as tested in accordance with AMCA Standards 210 and 300. Submit data for Fan airflow measuring devices, piezometers, as scheduled/specified.
- c. Fan Performance Curves (computer selection): Submit curves for all fans with system performance shown. Curves shall include plotted rpm, brake horsepower, horsepower, cfm, static pressure, and fan surge line and operating point.
- d. Coils: Performance data (computer selection printout certified in accordance with ARI 410) and catalog cuts.
- e. Humidifier: Performance data, capacity (pounds moisture per hour), plant steam flow and pressure, airflow, air velocity, dispersion panel dimensions and absorption distance.
- f. Dampers: Damper assemblies, including all damper sections, jackshafts and quantity, model numbers, and location of damper actuators. Show torque calculations to ensure that the actuators close the dampers to the specified leakage rate. Show calculations of the leakage at the actual design pressure. Submit product data and performance characteristics for all combination damper/airflow measuring stations as scheduled/specified.

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- g. Filters and Filter Rack Assemblies: Submit product data with performance characteristics. Submit all product data, wiring diagrams and control diagrams, performance characteristics/maintenance requirements/service information.
 - h. Sound power levels for housing inlet, outlet and radiation at rated capacity. List discharge and radiated sound power levels in tabular form in direct comparison of maximum allowable sound levels. (Combine all sources for reporting purposes.)
 - i. Submit electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field installed wiring.
 - j. Submit electrical products including panels, transformers, disconnect switches, variable frequency drives, circuit breakers, lighting, switches, shipping split connectors, and all other appurtenances/elements specified and required to fully power and control the custom air handler.
 - k. Catalog cuts/product data sheets of all components manufactured by others, including but not limited to; variable frequency drives, air filters, air intake/return louvers, vibration isolation, etc. indicating product data, model, dimensions, weights, performance, electrical power, materials, and finishes.
- 3. Calculations: submit the following:
 - a. Air pressure drop and total static pressure calculations.
 - b. Structural calculations for sizing and location of AHU base rail support, AHU details, and elevations.
 - 4. Certified AMCA Ratings: Submit ratings for air and sound performance (fans), and air leakage and air performance (dampers).
 - 5. Submit factory acceptance test and site acceptance test procedures.

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D. Submission Requirements

1. Submit shop drawings and product data with such promptness and in such sequences to cause no delays. Approval or other appropriate action on such submittals will be taken with such reasonable promptness as to cause no delays, while allowing sufficient time, in Owner's Representative's judgment, to permit adequate review.
2. For initial submission and for resubmissions that are required for approval, submit one (1) electronic copy of each drawing to Owner's Representative in accordance with vendor data submittal requirements.
3. Submit one (1) electronic copy to Owner's Representative of each drawing that is being resubmitted for record as a result of the application of "REVIEWED AS NOTED" on previous submissions.

E. Resubmission Requirements

1. Identification of Changes: Clearly identify changes made from initial submittal other than those requested by the Owner. Owner's Representative will review only those changes requested and those identified by manufacturer.

F. Owner's Representative Review of Submittals

1. Owner's Representative approval of shop drawings and product data submitted by the manufacturer shall not relieve the manufacturer of responsibility for deviations from requirements of Purchase Order documents, unless manufacturer has specifically informed Owner's Representative in writing of such deviation at time of submittal, and Owner's Representative has given written approval to specific deviation. The manufacturer shall continue to be responsible for deviations from requirements of Purchase Order documents which have not been specifically noted by the manufacturer in writing, and specifically approved by Owner's Representative in writing.

G. Operating and Maintenance Data

1. General: Maintenance and operating manuals in accordance with Section 01 00 00, GENERAL REQUIREMENTS. Include instructions for lubrication, filter replacement, motor and drive replacement, spare part lists, and wiring diagrams.

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2. Prepare and furnish for Owner's Representative's approval and subsequent use, one (1) electronic copy and three (3) operating and maintenance instruction manuals for each unit. Manuals shall be specific for this project. Include Table of Contents and/or Index and assemble instructions in durable, hardback, 3-ring loose-leaf binders. Details as follows:
3. Manuals shall contain complete written instructions on operation, care and maintenance of each piece of equipment/system and installation as a whole. Operating and maintenance instruction manuals shall be prepared, submitted and accepted by Owner's Representative prior to training specified further herein and acceptance of the Work by Owner's Representative.
4. Operating and maintenance instruction manuals shall be provided including detailed descriptions of equipment/system operation and shall include preventive maintenance procedures specifying requirements for frequency of inspection, cleaning, oiling, greasing, and adjusting and other attention in accordance with air handling unit manufacturer's requirements. O&M manuals shall also include each internal component manufacturer's specific recommended trouble-shooting tasks and detailed preventative maintenance work plans including all necessary steps and frequency.
5. Manuals shall include manufacturer's brochures, catalog cuts, parts lists, spare parts lists, wiring diagrams, and similar pertinent data. Manuals shall also include complete set of approved submittals bound together with operating and maintenance instructions for respective piece of equipment/system.
6. Manufacturer's operating and maintenance data shall be clearly marked to show equipment/system name and abbreviated designation. Data shall be specifically prepared for equipment/system involved and clearly define necessary operating and maintenance requirements.
7. Include manufacturer's phone numbers and other data necessary for VAMC to obtain expedient warranty service.
8. Include copy of factory and site acceptance test reports.

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9. Furnish additional operating and maintenance data as may be specified in PART 2.
10. Operating and maintenance instructions shall also include, but not be limited to the following:
 - a. Tools recommended for proper maintenance
 - b. Recommended lubricants
 - c. Hazards
 - d. Cleaning
 - e. Warranties and bonds
 - f. Maintenance agreements and similar continuing commitments
- H. Submit written test procedures two weeks prior to factory testing. Submit written results of factory tests for approval prior to shipping.
- I. Completed System Readiness Checklists provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 23 08 00 COMMISSIONING OF HVAC SYSTEMS.
- J. 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 on site.

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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

1.5 IDENTIFICATION

- A. Identify the air-handler with a permanently attached, corrosion-resistant 2" x 6" (minimum) nameplate. Nameplate shall be minimum 16 gauge stainless steel with at least 3/16" high lettering stamped into nameplate prior to attachment of nameplate to equipment.
- B. Nameplate lettering data shall be as follows:
 - Customer Equipment Tag No. _____
 - Owner's Representative Reference No. _____
 - Purchase Order No. _____
 - Manufacturer's Project No. _____
 - Manufacturer's Serial No. _____
 - Year Built _____
 - Mfg.'s Model No. _____
 - Design Data (i.e., design cfm, static pressures, fan rpm, motor amperage, horsepower, etc.) _____
 - Electrical Data _____
 - Standard Mfg.'s Data _____
 - ETL Listing Number _____
- C. Provide permanently attached directional rotation arrow, painted to contrast with background, on items of rotating equipment.

1.6 GUARANTEES/WARRANTIES

- A. Include the following with technical data required with quotation:
 1. Terms of manufacturer's standard warranty and costs (if any) associated therewith. A minimum warranty of 12 months from date of final acceptance is required. If final acceptance of unit does not occur within 6 months from date of shipment due to fault of the unit manufacturer, warranty shall be extended to account for delay and maintained at 12 months from date of final acceptance.
 2. Complete data on manufacturer's optional extended warranties and service contracts available including costs and details

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associated with each option. During warranty period the manufacturer shall provide labor and materials necessary to repair or replace, at his expense and without additional cost to VAMC, materials, equipment or workmanship in which defects may develop.

B. Include the following with Purchase Order submittals:

1. Details of warranty or warranties purchased.
2. Manufacturer's guarantee on equipment performance that is published in manufacturer's cataloged application and specification data.

1.7 DELIVERY, STORAGE AND HANDLING

- A. Seal fluid and air openings prior to shipment.
- B. Deliver products to site in protective containers, with factory installed shipping skids and lifting lugs.
- C. Coordinate maximum shipping split dimensions.
- D. Indicate VAMC Purchase order number and equipment number on the outside of each section delivered.

PART 2 - PRODUCTS

2.1 AIR HANDLING UNIT

- A. Custom Indoor Central Station Air Handling Unit shall be factory fabricated by an experienced manufacturer with all of the internal capabilities to factory fabricate, assemble, test, disassemble, ship to site and site verify/test the proper assembly and operation of the complete equipment module specified herein and shown on the design drawings/ equipment schedules and details.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Air Enterprises
 2. Buffalo Air
 3. Energy Labs

2.2 SCOPE OF WORK

- A. Provide air handler suitable for indoor installation and mounting, with components, construction and capacity as specified.

2.3 GENERAL REQUIREMENTS

- A. Air handling unit, having capacity, arrangement and other characteristics shown on drawing schedules and/or data sheets, shall

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be provided and shall generally consist of factory-engineered modular sections with casings and components as specified further herein.

B. Standard Construction

1. The equipment shall be the manufacturer's standard construction wherever possible.

C. All components requiring normal service and maintenance shall be identified and shall be easily accessible for service. The vendor shall specify clearances required around the equipment for normal service.

D. Fans shall be rated in accordance with ASHRAE Standard 51/AMCA Standard 210-74 and shall be licensed to bear AMCA Seal. Coils shall be computer-selected based on ASHRAE calculation procedures or be rated in accordance with ARI Standard 410.

E. Acoustic performance shall be as follows:

1. Casing radiated sound pressure level at 3 feet from exterior of unit (including beneath the unit floor) shall not exceed 60 dBA.
2. Relief Air Discharge sound pressure level measured 3 feet from exterior of unit shall not exceed 80 dBA. Airborne sound pressure level measured at supply duct connection to AHU casing/air tunnel/at smoke damper shall not exceed 95 dBA.
3. Airborne sound pressure level measured at 3 feet from the outdoor air inlet air section/louvers shall not exceed 70 dBA. Provide rain resistant louvers. Sound attenuating inlet/weather hoods shall be provided if specified sound pressure levels are exceeded.
4. Provide sound power levels in a minimum 7 octave bands for radiated noise at rated capacity.
5. Test methods and facilities used to establish sound transmission loss values shall conform explicitly to the ASTM Designations E90 85 and E413 73.
6. Test methods and facilities used to establish sound absorption values shall conform explicitly to the requirements of the ASTM Standard Test Method for Sound Absorption Coefficients by the Reverberation Method: ASTM C42384A and 795 83.

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- F. Air handling units, accessories, and components shall be designed and constructed to meet the following seismic forces:
1. Occupancy Category = II
 2. Importance Factor $IS = 1.0$
 3. Design Spectral Response parameters (Short Periods): $S_{DS} = 0.171g$
 4. Design Spectral Response parameters (Long Periods): $S_{D1} = 0.374g$
 5. Seismic Design Category = A
 6. Site Class = D
- G. Include lights, electrical devices and wiring as specified further herein.
- H. Unless restricted by shipping and rigging requirements units shall be shipped factory-assembled and ready for mechanical and electrical connections. If units must be shipped in sections or disassembled sections, unit manufacturer shall furnish hardware and gasketing and include complete assembly and installation instructions. Arrange shipping splits to minimize number of sections and include number of sections along with bid. Equipment and materials shall be covered and protected against dirt, water, chemicals and damage during shipment.

2.4 UNIT CONSTRUCTION

- A. Unit shall employ aluminum material (panels, bases, supports, safing, etc.) to reduce overall unit weight and minimize facility maintenance requirements.
- B. Provide safing between internal components and unit casing to prevent air bypass. Safing material shall match unit interior. All seams or voids between safing, components and unit casing shall be caulked and sealed airtight.
- C. Provide hygienic unit design with interior suitable for washing down. The use of support members framed within the unit casing which will allow for trapping of debris between the supports and casing will not be allowed. Unit insulation must be completely encapsulated.
- D. Base Frame
1. Each unit or shipping section shall be mounted on an insulated, one piece welded frame, fabricated from aluminum shapes. Sufficient internal framing and stiffeners shall be provided,

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along with properly located lifting lugs to allow for the rigging and handling of the unit.

2. Aluminum bases do not require painting.

Minimum base height, heating coil mounting height, humidifier mounting height and cooling coil mounting height up off floor of AHU air tunnel shall provide sufficient clearance for, drain pan trap seals and cooling coil condensate drain trap seal without disturbing the finished service corridor floors (assuming air handling unit air tunnel floor matches the line of the floor of the service corridor. Coordinate details of air handling unit drain pans to discharge into floor drains above the line of the floor.

E. Casing

1. The unit casing shall be double-wall, insulated sandwich construction or insulated panels supported by internal channel framing designed to limit panel deflections to 1/200th of any span at the design fan total pressure plus any snow and wind loads. Floor panels shall have additional internal structural channels for walk-on duty and full support of components.
2. Casing (interior and exterior) shall be 0.04" thick aluminum sheets. Aluminum sheets shall be of aluminum alloy 3003-H14 and conform to ASTM B209. Interior panels shall be solid, smooth aluminum sheets. In all cases, panel sheet thickness shall be increased where necessary to meet the deflection criteria cited above. All dissimilar metals shall be electrically and thermally isolated to prevent galvanic action.
3. The insulation material (between the inner and outer sheets) shall consist of 3 lb./CF density polyisocyanurate foam with a thickness to meet a minimum R value of 12. Insulation shall conform to ASTM E84, NFPA 255 and UL 723 and shall meet local code requirements. Insulation thickness or density shall be increased as required to prevent condensation as required in paragraph below.
4. Provide manufacturer's standard thermal break throughout entire unit casing between supports and panel sheets. Thermal break

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shall prevent condensation at design operating conditions and an outdoor condition of 99F dry bulb temperature and 77F wet bulb temperature. Thermal break joint construction shall consist of ½" structural epoxy bridge creating a true "no-thru" metal construction. Screws thru gaskets to adjoin casings is not acceptable.

5. The entire custom AHU air tunnel enclosure shall be constructed to maintain a maximum air leakage rate not in excess of 1 percent of total AHU air flow or 30 cfm whichever is greater at 125% of design internal negative or positive static pressure. Worst case static pressure shall apply for complete positive or negative section.
6. Ductwork systems and sections within the AHU for supply and return shall be tested in accordance with specified and scheduled duct leakage requirements.
7. All threaded fasteners and mounting hardware shall be stainless steel. Aluminum closed rivets may be used with units with aluminum framing.
8. Extend piping and conduit through unit casing as specified further herein. Provide unions or flanges on extended piping to allow for coil removal. Cap or plug open ends of piping and conduit before shipping. All penetrations through the unit casing shall be fully sealed with silicone sealant appropriate for the casing material.
9. Access doors shall be provided where indicated on drawings and as specified herein. Provide removable/replaceable panels where required to remove fans and coils. Panels shall be designed and constructed with suitable framing, gasketing and fastening devices such that removal and replacement may be accomplished without disturbing adjacent panels. Air tight integrity shall be maintained.
10. Provide safing between internal components and unit casing to prevent air bypass. Safing shall be of same material as casing of internal component, of suitable gauge and properly braced and reinforced as required. Voids between safing, components and unit

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casing shall be caulked and sealed airtight. Provide 304 stainless steel safing for cooling coils and humidifiers.

11. Provide Vent-Lok instrument test ports before and after sections which have changes in pressure, temperature, or humidity. Ports shall be gasketed threaded sleeves, caulked and sealed, and provided with threaded cap.
12. Sheet metal seams shall be caulked watertight. Exterior seams shall receive additional caulking as required. Caulks and sealants shall be FDA-approved, silicon-based, non-drying type suitable for aluminum surfaces. All internal joints and seams shall be caulked.
13. Roof shall be sloped a minimum of 1/8 inch per foot for drainage. Roof panel seams shall be sealed with acrylic sealant, gasketed screws and weatherproof caps or single membrane weather covers. Pitch of roof shall be in the long dimension of the AHU towards supply plenum discharge end. See Contract Drawings for additional information.

F. Floor

1. The unit base shall be provided with sloped sumps in areas as indicated on the drawings. Sumps to be welded and guaranteed waterproof to serve as a drain pan to prevent building water damage from the unit. Sump to be double-sloped (min. ¼" per foot) towards units drains to positively remove condensate from the unit.
2. The base floor shall be minimum 3/16" thick aluminum plate welded at all joints and to structural members. Floor material shall have smooth surface. The base floor shall be designed for a minimum live load of 100 pounds per square foot throughout the unit. The base floor is to be supported with adequate stiffening members to prevent oil canning. Caulking, gaskets and mechanical fasteners to guarantee seals and water tightness of joints will not be acceptable.
3. The perimeter support members shall be a minimum of 6" structural member properly sized to support all major components and the housing during rigging, handling and operation of the unit.

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4. The underneath side of the base pan and base perimeter shall be insulated with minimum 2" thick 1.5-pcf high density polyisocyanurate foam insulation to form a vapor barrier. Vapor barrier is then protected by a 0.040" thick aluminum sheet attached to the bottom of the base.
5. Each section of the unit base shall contain a minimum 1" NPT drain to facilitate system washdown, maintenance and condensate removal. Areas in the base where potential standing water cannot be removed through drains or weep holes are not acceptable. Clean out drains shall be provided with removable caps of non-corrosive material.
6. All equipment within air handling unit shall be provided with a minimum 2" high base to raise equipment off unit floor for housekeeping.
7. Supply air openings to be framed with 2" high water dam continuously welded to the pan to allow proper duct connections and to prevent moisture from entering the openings. Framed openings shall be provided with removable aluminum or 304 stainless steel grating designed and fabricated for a live load of 100 pounds per square foot.
8. All unit base service openings shall be framed with a minimum 2" high water dam continuously welded to the floor. All pipe and electric conduit chases with openings to building or elements shall be covered with thin gage aluminum or 304 stainless steel. Penetrations by contractors shall be sealed by the respective contractor.
9. Fastening to floor plate or joining of unit sections to be accomplished by bolting through gasketed joints above the floor line or continuously welding. Fasteners which penetrate base floor plate are not acceptable.
10. Unit to be provided with properly located permanent lifting plates or removable lifting lugs for each section to adequately allow rigging of the unit sections in place.

G. Access Doors

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1. Hinged access doors shall be provided on one side in sections requiring regular inspection or maintenance (coils, dampers, humidifiers, etc.). Removable hatches or panels shall be provided in addition to access doors to facilitate removal of coils, fans or other equipment as shown on drawings.
2. Doors shall be similar in design and construction to the exterior wall panels. Each door shall be mounted with a continuous stainless steel piano type hinge or approved equal in a heavy duty extruded aluminum frame. Doors shall open against static pressure.
3. Inside and outside chrome-plated door handles equipped with 2 or 3 point latching mechanisms and extruded rubber gasketing shall be used to close and seal the doors. Seals shall be replaceable. Doors shall be designed for tight closing to achieve the leak classification specified. Means for locking doors shall be provided.
4. Doors shall be of the maximum height that the unit will accommodate (up to 60"). Doors shall be provided with a minimum 12"x12" or 12" diameter view port of double thickness wire reinforced or tempered glass mounted in a gasketed frame.
5. For filter sections and other areas requiring regular access by maintenance personnel, the minimum door width shall be 24 inches. The minimum door width for fan access shall be 30 inches. The minimum door width shall be 18" for other areas. Refer to AHU configuration drawing for additional requirements.

2.5 OUTDOOR AIR INTAKE PLENUM SECTIONS

- A. Sections shall be provided with dampers as indicated by AHU configuration sketch, equipment schedule and/or datasheet.
- B. Provide access doors as indicated.
- C. OA intake plenum shall include minimum and maximum OA intake louvers and combination damper/airflow measuring stations. AHU openings/louver assembly frames shall be sealed air and water-tight and integrated into casing to prevent moisture and debris from entering the insulation space between inner and outer skin of the AHU walls.

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- D. Dampers shall be low leakage, opposed blade design capable of withstanding 8" wg differential pressure at 2,000 fpm approach velocity. Leakage rate not to exceed 6 CFM per ft.² at 4" wg differential pressure and 2,000 fpm approach velocity.
- E. Damper frames shall be made of extruded aluminum. Damper blades shall be extruded aluminum airfoil shape to withstand high velocities and static pressures. Dampers shall be provided with stainless steel blade end seals and flexible synthetic blade edge seals.
- F. Supply air discharge opening for AHU with minimum 8" flanged connection collar extended through unit opening and coordinated for sheet metal ductwork connection. AHU openings and collar connections shall be sealed air and water-tight and integrated into casing design to prevent moisture and debris from entering the insulation space between inner and outer skin of the AHU walls.

2.6 AHU SUPPLY AIR FANS

- A. General
 - 1. Each centrifugal supply air fan shall be plenum style, SWSI, furnished completely assembled and fitted with an electric motor, belt drive, inlet guard and adjustable vibration isolator base. Fans shall be sized to the performance requirements specified and shall be rated and certified in accordance with latest editions of ASHRAE and AMCA test codes and guaranteed by the manufacturer to deliver at the rated level. Fans shall be statically and dynamically balanced at the factory. Fan RPM shall not exceed 90% of the maximum allowable rpm for the class construction selected.
 - 2. Fans shall be capable of automated turndown through the design range from maximum to minimum conditions without stall, surge or increased vibration.
 - 3. First critical speed shall be at least 25 percent higher than anticipated maximum operating rpm.
 - 4. Provide an internal structural rail suitable for attachment of block and tackle. The rail shall facilitate lifting and transporting motor to the unit exterior. Rail shall be included in both the AHU fan section and within both sides of the service corridor outside the fan section extending to the closest service

corridor exit door. Rails shall also be extended to allow for removal/replacement of AHU coil/humidifier components.

B. Base

1. The fan and motor shall be mounted on a structural steel base isolated from the unit base with spring type vibration isolators. Isolators shall be selected in accordance with fan weight distribution such that fan rests level. Unit isolation efficiency: at least 90 percent. Provide thrust restraints as required. Provide concrete inertia base/filling with concrete at project site after final mounting/assembly as required per specifications. Include concrete weight in final operating weights submitted for AHU as required.
2. Fan discharge shall be connected to casing with a flexible neoprene connector. Duct connection shall be UL-listed and fire rated.

C. Wheels

1. Blades shall be of the non-overloading, double thickness airfoil type staggered on each side of the center plate. The wheel shall be keyed to the shaft and the key secured with setscrews

D. Cleaning & Painting

1. The completed assembly (entire fan, base, and wheels) shall be cleaned in accordance with the Steel Structures Painting Council (SSPC) SP-1, SP-2 and SP-3 to produce a rust and scale free surface. The interior and exterior surfaces shall then be primed and finished in accordance with manufacturer's standard specification. Aluminum wheels and components do not require painting.

E. Shafts and Hubs

1. The fan shaft shall be fabricated from solid AISI hot rolled steel which is accurately turned, ground, polished and ring gauged for accuracy.
2. Hubs shall be cast iron, straight bored, keyed and set screwed for positive attachment.

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F. Bearings and Drive

1. Bearings shall be foot mounted on a structural steel frame integral with the fan base and housing. Bearings shall have a minimum ABMA L-50 life of 1,000,000 hours (equivalent to L-10 life of 200,000 hours) at maximum operating conditions. Copper lubrication lines shall be provided from all bearings (and any other lubrication points) to a common area outside air handling unit air tunnel casing. All lubrication lines shall be labeled.
2. The fan drive guard and fan inlet guard shall be in accordance with OSHA requirements. The drive guard shall be a two-piece design split along the shaft centerlines such that the top half is easily removed and reinstalled. Designs requiring the use of hand tools to open the guard or resulting in loose fasteners are not acceptable. The guard shall contain tachometer openings for motor and fan sheaves as necessary for fan type.

2.7 COIL SECTIONS

A. General

1. Coils shall be removable without disturbing adjacent coils or equipment. Coils shall be rated by the manufacturer in accordance with ARI Standard 410 and shall be tested under water using 325 psig compressed air. Connections shall be copper with union or flanged ends extending through the unit casing. Unions shall be wrought copper with solder joint ends and copper seats. All water coils shall have top return connections to ensure proper venting. Drain and vent (or vacuum breaker for steam coils) connections shall be provided. All casing penetrations shall be sealed airtight. All coil headers shall be fabricated from minimum 0.060" wall seamless copper pipe and shall be brazed to the coil tube connections.
2. Coils shall be a maximum 10 feet wide and 4 feet high.
3. Piping for all coils shall be internally run and piped through AHU air tunnel casing walls by AHU manufacturer. All piping penetrations through AHU casing shall be factory gasketed, sealed air and water tight and pipe shall be capped.

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4. Mount heating coils and cooling coils as high as possible within the AHU to ensure the proper height for steam trap and cooling coil condensate drainage trap assemblies (above finished floor line. Provide supports to mount coil assemblies up and provide safing within AHU as required to allow elevated coil mounting.

B. Hot Water Coils:

1. Water coils shall be manufactured from 5/8" O.D. x 0.035" wall seamless copper tubing mechanically expanded and bonded to 0.0055" minimum thick aluminum fins with a maximum spacing of 10 fins per inch. Coil air pressure drop shall not exceed 1.2" w.g.
2. Coil casings shall be fabricated from 16 gauge type 304 stainless steel and shall incorporate intermediate tube supports for coils over 4'-0" long.
3. Coil banks shall have a maximum depth of 10 rows. If more than 10 rows are required, the coil shall be split into two sections with an access door between the sections.

C. Chilled Water Coils.

1. Chilled water coils shall be manufactured from 5/8" O.D. x 0.035" wall seamless copper tubing mechanically expanded and bonded to 0.0095" minimum thick copper fins with a maximum spacing of 10 fins per inch. Coil air pressure drop shall not exceed 1.2" w.g. when fully wet.
2. Coil casings shall be fabricated from 16 gauge type 304 stainless steel and shall incorporate intermediate tube supports for coils over 4'-0" long.
3. Coil banks shall have a maximum depth of 10 rows. If more than 10 rows are required, the coil shall be split into two sections with an access door between the sections.
4. Condensate pans shall extend the entire length of the coil including the header and return bends, as well as a minimum 12" downstream from the coil and 3" upstream of coil. Pan shall be sloped to promote positive drainage. Pan shall be fabricated from all welded, type 304 stainless steel and shall have a minimum depth of 3". Insulation similar to the unit casing shall be provided under drain pan. Pans shall have one drain connection

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sized for maximum condensate flow, but no less than 1-1/4" diameter. Pans shall have extension upstream of cooling coils or provide separate small lip/drain pan with separate drain.

5. An intermediate type 304 stainless steel drip pan shall be supplied with coils over 48" high and shall be factory piped to the main condensate pan. No insulation is required on intermediate drain pans. Piping shall be Type DWV hard-drawn seamless copper tubing, ASTM B306 with copper solder joint fittings. Pans shall have extension upstream of cooling coils or provide separate small lip/drain pan with separate drain extended down to lower drain pans/raised floor drain pan.
6. The design coil face area shall be sized to minimize carryover of condensate into the air stream. The maximum design face velocity for coils conditioning all outside air shall be 450 fpm. Systems that generally have 20% or less outside air shall be designed for a maximum 500 fpm face velocity.

2.8 FILTER SECTIONS

A. General

1. Each unit shall be supplied with pre-filters, after filters and final filters installed in frames designed and arranged for servicing through an access door located on the inlet side of the filter. Filter efficiency shall be as specified herein and shall comply with the minimum average efficiency as determined by the appropriate ASHRAE or IEST test method.
2. Filters shall be of fire resistant construction and shall comply with UL Class 2 requirements and shall be suitable for use in airstreams up to 190°F and 100% RH.
3. Filters shall be standard manufacturer's sizes.
4. Provide front face loading type housings.
5. Each filter section shall be provided with factory installed copper differential pressure ports across each filter extended to the outside of the unit housing.

B. Pre-filters (Pre-Filter 1)

1. Pre-filters shall be 2" thick (minimum) throwaway type with a minimum efficiency rating of MERV 8 as measured by the ASHRAE

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Standard Test Method (equivalent to 30 to 35% dust spot efficiency and greater than 90% Arrestance). The filter media shall be pleated, self-extinguishing non-woven cotton with trace polyester fibers. Maximum design velocity shall be 500 FPM. The media backer shall be 24 gauge, 1 inch square electro-plated, steel wire bonded to the media and secured in a heavy duty beverage board frame. Refer to schedule drawing for additional requirements.

2. Filter size shall be nominal 24" x 24" and/or 24" x 12". Refer to AHU configuration drawing for additional information. Consistent / all 24" x 24" filters are the preferred basis of design.

C. After Filters (Secondary/Pre-Filter 2)

1. After filters shall consist of a replaceable factory assembled cartridge-type element, incorporating a fiber glass medium and a corrosion resistant frame. Maximum design velocity shall be 500 FPM. Minimum efficiency rating shall be MERV 11 (equivalent to 60-65% dust spot efficiency and greater than 95% Arrestance) as measured by the ASHRAE Standard Test Method. The complete final filter assembly including the frame shall not exceed 12" in depth. Refer to schedule drawing for additional requirements.
2. After filter size shall be nominal 24" x 24" and/or 24" x 12". Refer to AHU configuration drawing for additional information. Consistent / all 24" x 24" filters are the preferred basis of design.

D. Final Filters (Within AHU/prior to AHU discharge)

1. Final Filters shall be mounted after the discharge of the supply fans within the AHU tunnel and shall be MERV 14 filters (equivalent to 90-95% dust spot efficiency and greater than 98% Arrestance) as measured by the ASHRAE Standard Test Method. Refer to schedule drawing for additional requirements.
2. Final filter size shall be nominal 24" x 24" and/or 24" x 12". Refer to AHU configuration drawing for additional information. Consistent / all 24" x 24" filters are the preferred basis of design.

E. Holding Frames for Pre-filters, After-filters and Final Filters

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1. Filters shall be installed in holding frames constructed of galvanized steel with minimum $\frac{3}{4}$ inch sealing flange and polyurethane foam gasket. Spaces between frames, casing, roofing and flooring shall be caulked, gasketed and sealed airtight. The filters shall be secured in the holding frame with gasketing and, where required, stainless steel retaining clips.

F. Air Purification-Filtration System (UV system). Refer to AHU configuration drawing, equipment schedules and details for additional information.

2.9 DAMPERS

A. General

1. Dampers shall be provided as indicated on the AHU sketch, data sheets and/or schedule.
2. Damper assemblies shall consist of airfoil type blades set in an extruded hat channel frame with mounting flanges on both sides of the frame. Aluminum construction shall be provided for outdoor air dampers. Galvanized construction may be used for other applications.
3. Dampers shall be low leakage design and shall be able to close against dead head pressure of the associated fan system without structural failure/deflection, etc. Damper blades shall be arranged in vertical or horizontal arrangement to help mitigate deflection/warping of blades/leakage. Leakage through a representative 48" x 48" damper at 4" W.G. pressure differential shall not exceed 7 CFM per square foot.
4. Dampers shall have an extended control shaft for installation of damper operator.
5. Maximum size for single section: 48" wide by 72" high. Split damper sections into multiple units accordingly. Ensure the overall assembly complies with dead head close off pressure requirements specified herein and for each respective fan per equipment schedules. Provide separate damper actuators and end switches as required. Coordinate damper section quantities and control points/airflow monitoring stations/wiring requirements with BAS contractor.

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6. Final damper sizes, actuator quantities and actuator placement must be coordinated for accessibility and maintenance requirements. For example, the minimum and maximum Outdoor air intake damper sizes and actuator locations must also be coordinated within outdoor air intake plenum and mounted on louver extension duct plenum assemblies (full size/face of louvers). Refer to AHU detail drawing and combination damper/airflow measuring station schedule for additional requirements. Coordinate clearance, mounting requirements and proper blade arrangement (in general/unless noted otherwise parallel blade for isolation/smoke dampers, opposed blade for mixing/modulating dampers).

B. Blades

1. Blades shall be of the airfoil type with integral structural reinforcing running the full length of each blade. Blade edges shall be provided with extruded vinyl seals secured in slots (in both blades and frame) without the use of cement. Blades shall be no more than 6" wide. Opposed blade design shall be used for OA intake and modulating applications.

C. Smoke Dampers

1. Where dampers are to be used as part of a smoke purge/control system, provide dampers that meet UL 555S Leakage Class I. Smoke dampers to be parallel blade. Refer to PEM detail drawing, control diagrams and sequences of operation for additional requirements. Refer to specifications section 23 31 00 for additional smoke damper requirements and specification section 28 31 00 for smoke detector requirements.

D. Fire Dampers

1. All fire dampers shall be dynamic dampers. Where fire dampers are required within ducts operating as part of a smoke purge/control system, provide 285 deg F fusible link. Refer to specification section 23 31 00 for additional fire damper requirements.

2.10 HUMIDIFIER SECTION

- A. Provide humidifiers of the following type and of size and capacity as indicated on the data sheets/schedule drawings.

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- B. All humidifier piping connections shall be internally run within air tunnel and piped through unit casing into the AHU service corridor. Pipe penetrations shall be factory gasketed and pipe shall be sealed and capped.
- C. Humidifier: Steam injection panel type, consisting of supply and condensate headers connected with a bank of vertical steam dispersion tubes. Each tube shall have 2 rows of diametrically opposed nozzles. Humidifier shall provide absorption characteristics that preclude water accumulation on unit surfaces beyond scheduled vapor trail distance.
- D. Tubes and header shall be contained in a stainless steel casing suitable for flanged air handling unit mounting.
- E. Tubes and headers shall be Type 316 stainless steel.
- F. Control valve shall be normally closed with a minimum of 7 psi spring range. Maximum flow through wide-open valve shall not exceed 133 percent of (1.33 times) scheduled flow rate and have a minimum Turn Down Ratio of 30 to 1 for $\frac{1}{2}$ inch and $\frac{3}{4}$ inch valves and 60 to 1 for larger valves. Valves shall be designed for ANSI 125/150 pound service and ANSI/FCI Class IV (or higher) leakage rating. Valves shall be sized for humidification range as required for AHU performance from 30% to 100% airflow capacity at design humidification outdoor air conditions. Provide 1/3 - 2/3, dual control valve arrangement if single control valve cannot adequately satisfy capacity control requirements.
- G. A blocking valve shall be provided.
- H. Provide individual F&T Traps to drain the header and the steam jacket manifold (where required/for jacketed style humidifiers). Run individual condensate lines directly to the outside. Refer to details and humidifier manufacturer piping diagrams for condensate drainage from dispersion panel style humidifiers (atmospheric pressure steam condensate).
- I. Provide electronic/analog modulating control valve actuator with position feedback
- J. Provide 316 stainless steel drain pan in humidifier section. Drain pan shall meet requirements as specified for the cooling coil section.

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- K. The humidifier shall be designed to minimize length of moisture plume to permit full vaporization without condensation of moisture on any internal surfaces. The air handling unit manufacturer shall follow the humidifier manufacturer's recommendations for minimum upstream and downstream clearances and mounting of high limit humidity sensor a minimum of 10 feet downstream of the humidifier dispersion tube assembly within the AHU discharge plenum.
- L. The air handling unit/humidifier manufacturer shall guarantee system performance including maximum plume length, and submit supporting calculations.
- M. Mount steam humidifier dispersion panel as high as possible within AHU air tunnel to allow for proper steam condensate trap height and installation of condensate traps above AHU service corridor floor line. Provide 316 stainless steel safing or aluminum safing matching interior AHU air tunnel panels all around humidifier dispersion panel to ensure air does not bypass humidifier dispersion tube assembly.

2.11 BAS/CONTROL REQUIREMENTS

- A. General
 - 1. AHU is intended to be a factory-wired piece of equipment with single point power connection. All building automation system controls shall be field installed by BAS/Controls Contractor.
 - 2. Coordinate location and wiring of all controls components to AHU mounted control panels. Ensure complete BACNET integration and mapping of all AHU measuring, monitoring, control and alarm points, allowing for remote control and monitoring of all AHU functions via existing site central BAS controls system.
- B. AHU Manufacturer and Controls Contractor Scope and Coordination
 - 1. Building automation systems/controls shall be fully coordinated between AHU manufacturer, component manufacturers and project controls contractor. Control devices, hardware, actuators, controllers, etc. shall be coordinated and supplied by controls contractor unless the specific piece of equipment/component is specified to include its own controls (e.g. airflow monitoring stations with integral damper assemblies, etc.)

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2. AHU manufacturer and controls contractor shall work carefully with all suppliers to ensure that the devices indicated on control diagrams and in sequences of operation are installed within the AHU. Installation of devices and hardware by Controls contractor for shall follow AHU manufacturer protocols carefully.

2.12 ELECTRICAL REQUIREMENTS

A. General

1. The AHU is intended to be a factory-wired piece of equipment with single point power connection and all electrical power equipment, components, devices, light fixtures, switches, receptacles, etc. in place and tested prior to shipment to project site.
2. The unit shall include all required panelboards, disconnect switches, step-down transformers, motors, variable frequency drives, smoke dampers, smoke detectors, lighting, GFCI receptacles, switches, etc.
3. Components and wiring methods shall comply with applicable and current standards of NFPA, IEEE, ANSI, NEMA and Underwriters Laboratories, Inc.
4. Complete electrical installation shall conform to requirements of current edition of the National Electrical Code, NFPA, OSHA and state codes, local codes or regulations having jurisdiction.
5. Factory wiring shall be enclosed in rigid aluminum conduit or EMT. 480-volt wiring shall be type THHN/THWN 600 V insulated wire. 120-volt wiring shall be a minimum No. 12 AWG, Type THHN/THWN insulated wire. All wiring to be stranded copper. Provide flexible liquid tight connections to fan and pump motors.
6. All wiring shall be run with a green insulated ground wire sized per the NEC. Minimum conduit size shall be 3/4".
7. All materials and installation methods shall be in compliance with the latest edition of NEC and the completed installations shall be factory tested. Components shall be labeled and wires numbered.
8. Junction boxes and covers where used in dry locations shall be galvanized steel. Junction boxes and covers where used in damp

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or wet locations shall be corrosion resistant, weatherproof, cast metal with threaded hubs and neoprene gasketing.

9. Fan and pump variable speed drives shall be provided by AHU manufacturer in accordance with specification section 26 29 11, MOTOR CONTROLLERS and will be mounted within the new penthouse equipment module. Coordinate each VFD enclosure type, configuration, size, mounting location within AHU as required to ensure proper access and to reduce exposure to heat/moisture within access areas/service corridor. Required Code clearances must be maintained.

B. Service Lighting and Utility Outlets

1. Custom AHU air tunnel, intake/relief/discharge plenums, AHU component access sections, fan and filter sections shall each be equipped with marine type light fixtures with a 150 watt equivalent, 120V compact fluorescent fixture. Provide low temperature ballast. Refer to AHU detail drawing for additional requirements. Carefully coordinate light fixture quantities and locations to provide adequate light levels in accordance with/similar to VAMC minimum guidelines for mechanical equipment/electrical rooms: 40 Foot Candles.
2. All AHU Internal Air Tunnel lighting shall be factory wired and controlled by light switches at the access door of each section end of the unit. Switch shall be wired to include a timer function, turning off lights after a set/programmable duration of time.
3. For units shipped in sections, light fixtures, switches, receptacles and any other 120V devices shall be factory wired to junction boxes with wiring coiled and tagged to facilitate field connection between sections and to terminal box.
4. Provide weatherproof covers for all receptacles and switches.
5. Provide appropriate weather-tight NEMA enclosures for all electrical and controls devices included with the AHU.

C. Motors

1. Motor specification, including efficiency, shall be in accordance with Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC.

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2. Design for operation with AC variable frequency drive controllers (VFD) for speed control application. Motor shall comply with all sections of NEMA MG-1 Part 31 compliant with 1600-volt insulation.
3. Motors rated less than 7-1/2 hp down to and including 1 hp (for which efficiency is not listed in EL-292) shall be of the premium efficiency type and the nominal efficiency percentage shall be the highest available from the acceptable motor manufacturers listed in EL-292.

D. Fan Motor Disconnect Switch

1. Provide factory-mounted and wired, lockable, fused disconnect switches for fans. Switch shall meet requirements of NFPA, local codes and have components that are UL-listed and labeled (Including an Arc Flash warning label.) Switch shall be mounted on access door side of fan section of the AHU.
2. Procedurally, these switches should not be opened while under load. Disconnect switches local to motors shall include an auxiliary contact that works in coordination with the disconnect switch handle so when the disconnect switch handle operates to open, the auxiliary contact will open and signal the VFD before the operator actually breaks the power.

E. Safety

1. Accessible external surfaces of equipment shall not exceed 60 degrees C (140 degrees F).
2. Products containing insulating liquids with polychlorinated biphenols (PCB) shall not be used.
3. Live parts shall be incapable of being inadvertently touched or approached nearer than a safe distance by a person.
4. Control voltage shall not exceed 120 Volts AC or 24 Volts DC. Where residual voltage may exist after disconnection of power source, provide warning sign.
5. Areas of panel where voltages above 120 VAC are present shall be clearly identified using warning labels.
6. Grounding and Bonding

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- a. Run insulated grounding conductor in electrical conduits and cables. Exposed noncurrent-carrying metal parts of equipment package shall be bonded and connected to grounding pad or terminal (for connection of Purchaser's ground wire). Bonding of flexible metal conduit over 3 feet using external copper bonding jumper, sized in accordance with NEC Article 250. Include ground wires within cable assemblies and connect at both ends to provide continuous fault current path source quality control.

PART 3 - EXECUTION

3.1 UNIT TESTING AND INSPECTION

A. General

1. Manufacturer shall be responsible for engineering, design, fabrication, inspection and testing, preparation for shipment, delivery and furnishing necessary documentation.
2. Owner's Representative reserves the right to inspect and witness testing of purchased equipment at any time. Owner's Representative shall have access to manufacturer's facility to inspect work in progress and witness factory testing. Access shall include areas involved in production of equipment and materials and subassemblies designated for that equipment. Access shall also be provided to such areas required for Owner's Representative to determine that proper fabrication and quality control procedures are being adhered to. Inspection and witnessing Factory Acceptance Testing (FAT) by Owner's Representative does not relieve manufacturer of his contractual obligations under terms of the Purchase order.
3. The complete unit shall be factory tested as an assembly to ensure compliance with this specification.
4. The manufacturer shall notify Owner's Representative and Engineer a minimum four weeks prior to the scheduled Factory Acceptance Testing. Owner's Representative will inform the manufacturer if project design team representative and Owner representative will witness the FAT. Manufacturer shall coordinate FAT timeframe with both the Government and A/E.

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5. Equipment shall not be shipped from the factory to the project site until Owner's Representative/VAMC COR has given their written approval.

B. Factory Tests and Factory Acceptance Testing (FAT)

1. Manufacturer shall submit test procedures to Owner's Representative for approval at least 4 weeks prior to scheduled tests. Manufacturer shall clearly list all tests planned to be carried out prior to the owner-witnessed tests and exactly what tests would be witnessed by owner representatives. Owner reserves the right to request incorporation of any and all tests herein to be witnessed during factory visit. Final list of witnessed tests shall be agreed upon prior to arrangement of FAT and signed off on by Owner/VAMC COR. Tests not witnessed shall be completed prior to FAT and results of testing and any corrective actions taken included in report to Owner's Representative for sign-off prior to shipment to project site.
2. Tests shall display scheduled performance characteristics, using certified testing instruments provided by the manufacturer.
3. Vibration Test: The unit fans shall be operated at the design RPM with the final/actual variable frequency drives associated with each fan. A complete vibration spectrum shall be conducted. Such tests must be performed on a completely assembled unit including all components. Unit manufacturer shall demonstrate compliance with the fan manufacturer's recommended vibration tolerances. Fans designated for variable speed operation shall be tested and balanced for motor speeds from design maximum down to 20% in at least 20 percent increments. Vibration analysis to be performed by CVI/MISTRAS (OR APPROVED EQUAL).

Parameter (Order of 1x RPM)	Units	Vibration Level
Overall*	IPS (Peak)	0.2
Sub. to 1.5X RPM	IPS (Peak)	0.2
1.5 to 4.5X RPM	IPS (Peak)	0.15
4.5 to 20.5X RPM	IPS (Peak)	0.1
20.5 to 40.5x RPM	IPS (Peak)	0.11

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40.5 to 70.5X RPM	IPS (Peak)	0.1
1 to 20 kHz	RMS Acceleration (G's)	1.5
Time Wave Form	G's	No Impacting

4. Coil Pressure Test: The heating and cooling coils shall be tested per specified requirements. Any other piping included with the air handling units shall be pressure tested in accordance with the requirements of specifications.
5. Electrical Function Test: The entire electrical system shall be functionally checked including disconnect switches, panel boards, transformers, motors, variable frequency drives, lights, utility outlets, switches, unit heaters, etc., for proper operation.
6. Casing Deflection Test: Casing shall be checked for maximum deflection at design operating pressures.
7. Leakage Test: The assembled unit(s) shall be factory tested for air leakage within the custom air handling unit air tunnel and separately for the service corridor. This test shall demonstrate that the leakage requirements specified for the casing are met.
7. Fan Performance Test: Test fan performance at maximum and minimum design CFM and static pressures in accordance with submitted fan curves. Test per AMCA field test procedure acceptance criteria as per AMCA standard. Test and document temperature rise at fan section inlet and outlet during fan performance testing.
8. Acoustical Performance Tests: Confirm performance as specified herein. Measure and document acoustic performance and make necessary adjustments as specified.
9. The manufacturer shall, in addition to the above, perform all standard factory tests (including, but not limited to, tests of ductwork and piping leakage as required by their respective specification sections-tested prior to insulation, drain pan/floor drain leakage test, control and smoke damper/smoke detector operation testing, airflow measuring device tests, UV system tests, smoke purge sequence test, shut-down and start-up

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testing, etc.) and submit the test data to Owner's Representative prior to shipment. All deficiencies must be corrected before the unit is shipped.

10. All measurements shall be performed with calibrated instruments and documented.
11. Manufacturer shall provide copies of all factory test reports, including vibration and leakage testing.

C. Field Supervision and Site Acceptance Testing (SAT)

1. Where field assembly of custom air handling units is required, the manufacturer shall provide on-site assembly supervision by a qualified factory technician.
2. Manufacturer representative shall be present when unit(s) arrive and are unloaded at the project site. Provide erection supervision.
3. Provide start-up services to supervise the initial start-up of the air handler motor controllers including variable frequency drives. Minimum 2 days onsite. Provide written start-up procedures thirty (30) days prior to start-up of unit.
4. Repeat Factory Acceptance Testing as specified herein at the project site (SAT-Site Acceptance Testing). Provide accompanying SAT report similar to FAT report verifying results and comparing to results in factory. All deficiencies must be corrected prior to completion of project close-out. SAT report shall be used in conjunction with all required commissioning documents by the project Commissioning Authority.
5. Unit shall be furnished with shipping splits. Provide on-site assembly supervision by a qualified factory technician.
6. The assembled unit shall be field tested for air leakage within the AHU air tunnel using a calibrated orifice plate or flow tube. The AHU ductwork shall be tested again for leakage to confirm all flanges/permanently welded joints at shipping splits have been tightly sealed. Piping systems shall be retested for leakage.
7. Provide field vibration testing equivalent to factory testing procedures once AHU has been set on prefabricated AHU support dunnage as part of start-up services.

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8. Provide field acoustical performance testing equivalent to factory testing procedures once AHU has been fully assembled and site acceptance testing begins. Perform this testing early to ensure there are no noise concerns at OA intake, relief, exterior panels. Coordinate all other equipment/component testing and verification requirements in compliance with project commissioning/testing and verification specifications. Coordinate with project commissioning agent/VAMC COR.
9. Confirm installing contractor coordinates all equipment support and flashing requirements and notes in start-up report.
10. All start-up action shall be documented. Start AHU according to manufacturer's instructions. Operate, adjust and verify all controls and safeties.

3.2 CLEANING PRIOR TO SHIPMENT

- A. Interior and exterior surfaces shall be cleaned to remove dust, dirt, oil, grease, rust inhibitors, metal flakes, chips, residues from manufacturing and assembly processes and other foreign materials.
- B. Water, oil, or other liquids used for cleaning or testing are to be drained from equipment before shipping. Oils required for proper operation shall be replaced and maintained at proper levels.

3.3 PREPARATION AND SHIPMENT

- A. Machined surfaces including faces of mild steel flanges shall be protected and coated with suitable rust preventive coating.
- B. Openings shall be sealed to prevent entrance of foreign materials. Flange faces shall be protected with wooden or plastic flange covers, taped to provide waterproof protection. Threaded connections shall be protected with plastic thread protection caps.
- C. Accessories and parts which are shipped loose shall be boxed and properly identified with durable shipping tags that are securely attached to each package and marked with its related equipment name, assembly location, Purchase Order number, assembly series number (if applicable), shop order number and purchaser's name. Separate packages for a single item shall also be marked so as to identify component(s) in each package, and number of packages in each shipment.

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- D. Parts shall be adequately braced, protected, and packaged to prevent damage during shipment. Unit section(s) shall be shrink-wrapped to protect the unit during shipment.
- E. The Purchase Order Number, Equipment Item Number and Vendor order/tracking number shall be prominently displayed on equipment skids and shipping containers or crates.
- F. Adequate instruction, labeled "Special Lifting and Handling" shall be attached if special handling and unpacking are required.

3.4 DELIVERY

- A. Manufacturer shall furnish and ship equipment.
- B. Manufacturer shall pack, crate and protect equipment to prevent damage from handling, weather, shock, vibration, water and corrosion during shipment. Wrap packaged or crated assemblies in weatherproof plastic sheeting prior to shipment.
- C. Manufacturer shall include complete handling and installation data with equipment when shipped to the job site.
- D. Damaged equipment will not be accepted at the job site.

3.5 COMMISSIONING (INSTALLING CONTRACTOR)

- 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
- C. Verify that building automation/BAS controls and electrical wiring installation complies with manufacturer's submittal and installation requirements of Division 23, 26 and 28 Sections. Do not proceed with AHU startup until wiring installation is acceptable to equipment installer.
- D. Start AHU according to manufacturer's instructions.
- E. Operate and adjust controls and safeties.
- F. All start-up action shall be documented.

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3.6 DEMONSTRATION (MANUFACTURER)

- A. Factory-authorized service representative shall demonstrate AHU and train Owner's maintenance personnel. Minimum 1 day on site. Submit course agenda three (3) days prior to training session. Provide resume of training instructor and record the training session and turn over DVD, CD or tape to owner.
- B. Operate AHU including accessories and controls, to demonstrate compliance with requirements.
- C. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.
- D. Engage a factory-authorized service representative of the supply fan manufacturer to train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans. Refer to Division 1 Section "Demonstration and Training."
- E. Schedule training with Owner with at least forty (40) days advance notice.
- F. All training shall be documented.

3.7 EXAMINATION (INSTALLING CONTRACTOR)

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine casing insulation materials and filter media before air-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for steam, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.8 INSTALLATION (INSTALLING CONTRACTOR)

- A. Equipment Mounting: Install air-handling unit without vibration isolation devices.
- B. Arrange installation of units to provide access space around air-handling units for service and maintenance. Do not operate fan system

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until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.

- C. Install filter-gage, static-pressure taps upstream and downstream of filters. Mount filter gages on outside of filter housing or filter plenum in accessible position. Provide filter gages on filter banks, installed with separate static-pressure taps upstream and downstream of filters.

3.9 CONNECTIONS (MANUFACTURER)

- A. Comply with requirements for piping specified in other Division 23 Sections. Drawings and applicable details indicate general arrangement of piping, fittings, and specialties.
- B. Install piping within service corridor to allow service and maintenance. Connect to each coil, humidifier, etc. without blocking access into AHU air tunnel via access doors/access door swings, etc. AHU manufacturer shall extend all component piping through AHU casing for connection/continuation by installing (mechanical) contractor. .
- C. Connect piping to air-handling unit mounted on vibration isolators with flexible connectors.
- D. Connect to condensate drain pans using NPS 1-1/4, ASTM B 88, Type M copper tubing. Extend to floor drains without creating a tripping hazard and to promote proper drainage to adjacent floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction. AHU air tunnel drain pans shall 304 stainless steel and shall be raised as indicated herein to ensure proper trapping as specified and indicated by trap details. Coordinate all drainage piping locations for field piping extending up from below AHU floor.
- E. Chilled-Water and Heating Hot Water Piping: Comply with applicable requirements in Division 23 piping specifications and piping/valve specifications. Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection. Refer to piping and component details and pipe/insulation material schedule for additional requirements.

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- F. Steam and Condensate Piping: Comply with applicable requirements in Division 23 steam and condensate specifications and piping/valve data sheets. Install gate valve and inlet strainer at supply connection of dry steam humidifiers, and inverted bucket steam trap to condensate return connection. Refer to piping and component details and pipe/insulation material schedule for additional requirements.
- G. Ductwork: Comply with applicable requirements in Division 23 ducts and casings specifications. Connect ductwork to air-handling units mounted on vibration isolators with fire rated flexible connections. Refer to contract drawings for additional requirements.

3.10 ADJUSTING (INSTALLING CONTRACTOR)

- A. Adjust damper linkages for proper damper operation.
- B. Comply with requirements in Division 23 Section "Testing, Adjusting, and Balancing" for air-handling system testing, adjusting, and balancing.
- C. Comply with requirements in Specification Sections 01 91 00, GENERAL COMMISSIONING REQUIREMENTS and 23 08 00, COMMISSIONING OF HVAC SYSTEMS. Installing contractor shall coordinate efforts of all disciplines for rigging/mounting, utility connections, BAS/controls integration to site BAS, TAB, Site Testing/Verification/Commissioning efforts, etc.

3.11 CLEANING (INSTALLING CONTRACTOR)

- A. After completing system installation and testing, adjusting, and balancing air-handling unit, Heating hot water system and air-distribution systems and after completing startup services, clean air-handling unit air tunnel/internal components to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.
- B. Interior and exterior surfaces shall be cleaned to remove dust, dirt, oil, grease, rust inhibitors, metal flakes, chips, residues from rigging and assembly processes and other foreign materials. Water, oil, or other liquids used for cleaning or testing are to be drained from equipment before shipping. Oils required for proper operation shall be replaced and maintained at proper levels

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3.12 STARTUP SERVICES

- A. The custom air handling unit, including but not limited to the return/relief fans, coils, etc. shall not be operated for any purpose, temporary or permanent, until AHU is clean, ductwork is clean, piping is clean, piping system has been flushed and filled, water treatment complete, AHU air filters are in place and active, fan bearings are lubricated and fans have been test run (including site noise & vibration testing) under observation.
- B. After the complete custom air handling units, including but not limited to the return/relief fans, coils, etc. is installed and tested/verified/commissioned, provide startup and operating instructions to VA personnel.
- C. An authorized factory representative should start up, test and certify the final installation and application specific calibration of control components. Items to be verified as part of site acceptance testing include: fan performance over entire operating range, noise and vibration testing, verification of proper fan alignment, AHU air tunnel site leakage testing, final ductwork and piping leakage testing, overall inspection of the installation, Owner/Operator training, etc.
- D. Provide training and instruction for VA engineering, operations and maintenance personnel in accordance with Article, INSTRUCTIONS, of Section 01 00 00, GENERAL REQUIREMENTS, and Section 23 08 00, COMMISSIONING OF HVAC.

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SECTION 23 74 43

CUSTOM, OUTDOOR, CENTRAL-STATION AIR-HANDLING UNIT

PART 1 - GENERAL

1.1 SUMMARY

- A. This Specification defines engineering, design, materials of construction, fabrication, and performance requirements for CUSTOM, OUTDOOR, CENTRAL-STATION AIR-HANDLING UNITS.
- B. Definitions: Custom Outdoor Central Station Air-Handling Unit (COCSAHU): A factory fabricated assembly consisting of custom outdoor/rooftop central station air-handling unit, of supply and return/relief fans, heating/cooling/reheat coils, filters, humidifiers, single point power connection and other necessary equipment/components to perform one or more of the following functions of circulating, filtering/cleaning, heating, cooling, humidifying, dehumidifying, and mixing of air to deliver and return/relieve/smoke purge/evac from the existing spaces served by the current unit. The new unit is a piece of equipment designed to be fully powered and controlled and to be factory fabricated and tested prior to shipment to project site. Design capacities of units shall be as scheduled on the drawings.

1.2 RELATED WORK

- A. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS: Coordination of Factory acceptance/site acceptance testing with project start-up/controls validation and overall commissioning efforts.
- B. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS: Requirements for commissioning, systems readiness checklists, and VAMC training.
- C. Section 07 84 00, FIRESTOPPING.
- D. Section 23 05 11, COMMON WORK RESULTS FOR HVAC: General mechanical requirements and items, which are common to more than one section of Division 23.
- E. Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT: Sound and vibration requirements.
- F. Section 23 07 11, HVAC and BOILER PLANT INSULATION: Piping and duct insulation.

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- G. Section 23 21 13, HYDRONIC PIPING and Section 23 22 13 STEAM and CONDENSATE HEATING PIPING: Heating Hot Water (Reheat), Chilled Water, Cooling Coil Condensate, and Steam/Steam Condensate Heating, Cooling and Humidification Piping, Valves and Specialties.
- H. Section 23 82 16, AIR COILS: Heating, and cooling coils.
- I. Section 23 82 00, CONVECTION HEATING AND COOLING UNITS: Hydronic Unit Heaters - heating for service corridor/equipment access areas.
- J. Section 23 34 00, HVAC FANS: Return/relief and exhaust fans.
- K. Section 23 36 00, AIR TERMINAL UNITS: VAV Boxes for service corridor and equipment access areas.
- L. Section 23 31 00, HVAC DUCTS and CASINGS: Requirements for galvanized steel ductwork, stainless steel ductwork, sealants, fire rated flexible duct connectors, sound attenuators, fire dampers, smoke dampers, duct access doors and minimum requirements for pre-fabricated roof curbs and equipment supports.
- M. Section 23 40 00, HVAC AIR CLEANING DEVICES: Air filters and filters' efficiency.
- N. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC: HVAC controls.
- O. Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC: Testing, adjusting and balancing of air handling equipment, VAV Boxes, unit heaters, and Hydronic Pumps for air and water flows.
- P. Section 23 25 00, HVAC WATER TREATMENT: Chemical treatment for closed loop Hydronic systems.
- Q. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC: Motor types.
- R. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- S. Section 26 05 19, LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES.
- T. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.
- U. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS.
- V. Section 26 24 16, PANELBOARDS.
- W. Section 26 27 26, WIRING DEVICES.
- X. Section 26 29 11, MOTOR CONTROLLERS: Types of motor starters, variable speed/variable frequency drives.
- Y. Section 26 29 21, ENCLOSED SWITCHES AND CIRCUIT BREAKERS.
- Z. Section 26 41 00, FACILITY LIGHTNING PROTECTION.

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- AA. Section 28 31 00, FIRE DETECTION AND ALARM: AHU Isolation Smoke Damper Smoke Detectors and associated wiring.

1.3 QUALITY ASSURANCE

- A. Refer to Article, Quality Assurance, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Equipment shall conform to requirements of national, state and local regulating authorities and be furnished in accordance with current applicable sections of following codes and standards: AMCA, ASHRAE, IBC, IMC, SMACNA, ASME, NEC, NFPA, OSHA, UL, ARI, ANSI, NEMA and ASTM. In event of discrepancies between this Specification and codes or standards, manufacturer shall notify Owner's Representative.
- C. All products and composite package shall meet all applicable paragraphs of IEEE, NEC and NEMA Standards, shall be designed for installation in accordance with NEC, and shall be UL or ETL labeled.
- D. Equipment and material shall be new and of first quality and workmanship, free from defects and suitable for the specified use.
- E. Certifications: Manufacturer shall certify in writing compliance with Purchase Order documents, warranties provided, and manufacturer's field service and demonstration requirements specified.
- F. Air Handling Units Certification
1. Air Handling Units with Housed Centrifugal Fans: The air handling units shall be certified in accordance with AHRI 430 and tested/rated in accordance with AHRI 260.
 2. 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. Fans shall be rated in accordance with AMCA Standard 210 for performance and AMCA Standard 301 for sound and shall bear the AMCA seal. Motor shall meet requirements of NEMA, IEEE, ANSI, and NEC standard. Coils shall be rated in accordance with ARI Standard 410 and bear the ARI seal.

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- G. Heating, Cooling, and Air Handling Capacity and Performance Standards:
AHRI 430, AHRI 410, ASHRAE 51, and AMCA 210.
- H. 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.
- I. 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.
- J. Air Handling Unit and all associated internal components/appurtenances shall be tested and verified as a single piece of coordinated mechanical equipment. Documentation of factory acceptance testing / verification for the overall unit shall be submitted to VAMC COR prior to shipment from factory to project site.
- K. Provide an additional in field inspection and verification of the entire unit as a single piece of equipment after complete assembly at the job site. Field inspection is to be inclusive of all equipment in the unit including the structure. Non Corrosive, metal nameplate is to be permanently attached to the unit at the entrance showing the manufacturer's date of the field inspection/approval of the operational AHU.

1.4 SUBMITTALS

- A. The contractor shall, in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES, furnish a complete submission for all Custom Outdoor Central Station Air Handling Units covered in the project. The submission shall include all information listed below. Partial and incomplete submissions shall be rejected without reviews.

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B. The vendor shall submit the following data, drawings and information:

1. List of exceptions to specifications, drawing schedules, AHU diagram drawing and all associated details on line-by-line basis. Include proposed materials, methods and cost difference where substitutions are allowed.
2. Completed Data sheets. For fans, include curves with plots showing duty points at specified maximum and minimum operating conditions, efficiency and brake horsepower.
3. Representative outline or general arrangement drawings including overall dimensions and dimensions of field installed or assembled components.
4. System schematic drawings showing all components, instruments and control systems to be furnished with unit.
5. List of proposed manufacturers of fans, filters, coils, motors, drives, dampers, and other components within the AHU. Clearly note differences from scheduled basis of design manufacturers/noting equivalency as per submittal requirements.
6. Information on guarantees/warranties specified and on those available.
7. Recommended spare parts quotation for one (1) year operation.
8. Recommendation as to quantity of vendor supervision necessary for erection, commissioning and training with the estimated cost of services.
9. Calculations indicating that insulation thickness and thermal break will prevent condensation at design operating conditions.
10. Number of sections, and shipping, erection and operating weight of each section. Include dimensions and shipping weight of largest section of assembly that will ship as one piece.
11. Submit confirmation of design and coordination of pre-fabricated, insulated, equipment curb/rails to align with all shipping splits/base-rail support locations for mounting on new structural dunnage.
12. Overall power requirements and electrical data including V/PH/HZ for equipment/components that consume electrical power. Data for

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motors should also include HP, type, power factor and guaranteed minimum efficiency.

13. Schedule (indicated in weeks) for submittal of drawings for approval, start and finish of Factory Acceptance Testing (FAT) and shipment of units after receipt of approved drawings.

C. After Award Requirements

Upon receipt of Purchase Order, prepare and submit shop drawings and product data prepared specifically for equipment being furnished, for use in fabrication and installation. Submittals shall show sufficient data to establish evidence of compliance with Purchase Order documents. After receipt of Purchase Order submit the following information:

1. Shop Drawings:

- a. Unit: Shop drawings showing all components, dimensions, weights, materials, gauges, finishes and module breaks. Include electrical wiring diagrams. Indicate service corridors, access doors, access panels and service clearances around equipment for normal servicing. Include fabrication and installation details. Provide sections and elevations to indicate AHU utility connections, piping and power drops through floor, etc. Include layout of electrical components such as panel boards, transformers, disconnect switches, motors, variable frequency drives, GFCI power receptacles, light switches and fixtures. Indicate layout of major components and required clearances for maintenance. Include coordinated anchoring information, material, sizes, type, spacing of anchor bolts, attachment to structural steel support member locations, flashing details matching architectural flashing details and other information required for coordination.
- b. Fans: Show fan layout, housing, materials, gauges, dimensions, weights, vibration isolation bases and installation details.

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- c. Provide shipping weights of major components such as fans and coils which may require removal/replacement. Include weights of removable/replaceable panels.
- 2. Manufacturer's Literature and Data:
 - a. General: Submittals shall include fans, drives, motors, coils, humidifiers, plenum mixing outside/return/relief air/smoke dampers, smoke detectors, dynamic fire dampers, filter housings, UV light air purification system, and all other related accessories/appurtenances. The contractor shall provide custom drawings showing total air handling unit assembly including dimensions, operating weight, access sections, flexible connections, vibration isolation, door swings, utility piping/power conduit, controls conduit chase and penetrations, electrical disconnects, power transformers, lights, duplex receptacles, switches, wiring, utility connection points, unit support system, motor removal rail systems, drain pans, floor drains, airflow and static pressure drops through each component (filters, coils, etc.), shipping splits and rigging points per section. Refer to drawings, controls diagrams, schedules and detail sheets for additional requirements.
 - b. Fans: Manufacturer's fan performance (data includes cfm, rpm, bhp, motor nameplate data, tip speed, outlet velocity, true critical speeds and static pressure) and sound performance (data includes sound power level ratings by octave bands) as tested in accordance with AMCA Standards 210 and 300. Submit data for Fan airflow measuring devices, piezometers, as scheduled/specified.
 - c. Fan Performance Curves (computer selection): Submit curves for all fans with system performance shown. Curves shall include plotted rpm, brake horsepower, horsepower, cfm, static pressure, and fan surge line and operating point.
 - d. Coils: Performance data (computer selection printout certified in accordance with ARI 410) and catalog cuts.

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- e. Humidifier: Performance data, capacity (pounds moisture per hour), plant steam flow and pressure, airflow, air velocity, dispersion panel dimensions and absorption distance.
- f. Dampers: Damper assemblies, including all damper sections, jackshafts and quantity, model numbers, and location of damper actuators. Show torque calculations to ensure that the actuators close the dampers to the specified leakage rate. Show calculations of the leakage at the actual design pressure. Submit product data and performance characteristics for all combination damper/airflow measuring stations as scheduled/specified.
- g. Filters and Filter Rack Assemblies: Submit product data with performance characteristics. Submit all product data, wiring diagrams and control diagrams, performance characteristics/maintenance requirements/service information for UV system.
- h. Sound power levels for housing inlet, outlet and radiation at rated capacity. List discharge and radiated sound power levels for sound attenuators in tabular form in direct comparison of maximum allowable sound levels. (Combine all sources for reporting purposes.)
- i. Submit electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field installed wiring.
- j. Submit electrical products including panels, transformers, disconnect switches, variable frequency drives, circuit breakers, lighting, switches, receptacles, shipping split connectors, and all other appurtenances/elements specified and required to fully power and control the custom air handler, and field installed devices such as unit heaters, control devices, pumps, etc.
- k. Catalog cuts/product data sheets of all components manufactured by others, including but not limited to; variable frequency drives, air filtration system, air intake/relief/exhaust louvers, intake/relief hoods, vibration

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isolation, etc. indicating product data, model, dimensions, weights, performance, controls, electrical power, materials, and finishes.

3. Calculations: submit the following:
 - a. Air pressure drop and total static pressure calculations.
 - b. Structural calculations for sizing and location of AHU base rail support members and equipment rails for mounting to structural steel dunnage as indicated by structural plans, AHU details and elevations.
4. Certified AMCA Ratings: Submit ratings for air and sound performance (fans), and air leakage and air performance (dampers).
5. Submit factory acceptance test and site acceptance test procedures.

D. Submission Requirements

1. Submit shop drawings and product data with such promptness and in such sequences to cause no delays. Approval or other appropriate action on such submittals will be taken with such reasonable promptness as to cause no delays, while allowing sufficient time, in Owner's Representative's judgment, to permit adequate review.
2. For initial submission and for resubmissions that are required for approval, submit one (1) electronic copy three (3) hard copy quantities of each drawing to Owner's Representative in accordance with vendor data submittal requirements.
3. Submit one (1) electronic copy and three (3) hard copy quantities to Owner's Representative of each drawing that is being resubmitted for record as a result of the application of "REVIEWED AS NOTED" on previous submissions.

E. Resubmission Requirements

1. Identification of Changes: Clearly identify changes made from initial submittal other than those requested by the Owner. Owner's Representative will review only those changes requested and those identified by manufacturer.

F. Owner's Representative Review of Submittals

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1. Owner's Representative approval of shop drawings and product data submitted by the manufacturer shall not relieve the manufacturer of responsibility for deviations from requirements of Purchase Order documents, unless manufacturer has specifically informed Owner's Representative in writing of such deviation at time of submittal, and Owner's Representative has given written approval to specific deviation. The manufacturer shall continue to be responsible for deviations from requirements of Purchase Order documents which have not been specifically noted by the manufacturer in writing, and specifically approved by Owner's Representative in writing.

G. Operating and Maintenance Data

1. General: Maintenance and operating manuals in accordance with Section 01 00 00, GENERAL REQUIREMENTS. Include instructions for lubrication, filter replacement, motor and drive replacement, spare part lists, and wiring diagrams.
2. Prepare and furnish for Owner's Representative's approval and subsequent use, one (1) electronic copy and three (3) operating and maintenance instruction manuals for each unit. Manuals shall be specific for this project. Include Table of Contents and/or Index and assemble instructions in durable, hardback, 3-ring loose-leaf binders. Details as follows:
3. Manuals shall contain complete written instructions on operation, care and maintenance of each piece of equipment/system and installation as a whole. Operating and maintenance instruction manuals shall be prepared, submitted and accepted by Owner's Representative prior to training specified further herein and acceptance of the Work by Owner's Representative.
4. Operating and maintenance instruction manuals shall be provided including detailed descriptions of equipment/system operation and shall include preventive maintenance procedures specifying requirements for frequency of inspection, cleaning, oiling, greasing, and adjusting and other attention in accordance with air handling unit manufacturer's requirements. O&M manuals shall also include each internal component manufacturer's specific

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recommended trouble-shooting tasks and detailed preventative maintenance work plans including all necessary steps and frequency.

5. Manuals shall include manufacturer's brochures, catalog cuts, parts lists, spare parts lists, wiring diagrams, and similar pertinent data. Manuals shall also include complete set of approved submittals bound together with operating and maintenance instructions for respective piece of equipment/system.
6. Manufacturer's operating and maintenance data shall be clearly marked to show equipment/system name and abbreviated designation. Data shall be specifically prepared for equipment/system involved and clearly define necessary operating and maintenance requirements.
7. Include manufacturer's phone numbers and other data necessary for VAMC to obtain expedient warranty service.
8. Include copy of factory and site acceptance test reports.
9. Furnish additional operating and maintenance data as may be specified in PART 2.
10. Operating and maintenance instructions shall also include, but not be limited to the following:
 - a. Tools recommended for proper maintenance
 - b. Recommended lubricants
 - c. Hazards
 - d. Cleaning
 - e. Warranties and bonds
 - f. Maintenance agreements and similar continuing commitments
- H. Submit written test procedures two weeks prior to factory testing. Submit written results of factory tests for approval prior to shipping.
- I. Completed System Readiness Checklists provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 23 08 00 COMMISSIONING OF HVAC SYSTEMS.
- J. Submit shipping information that clearly indicates how the units will be shipped in compliance with the descriptions below.

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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 on site.
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

1.5 IDENTIFICATION

- A. Identify the air-handler with a permanently attached, corrosion-resistant 2" x 6" (minimum) nameplate. Nameplate shall be minimum 16 gauge stainless steel with at least 3/16" high lettering stamped into nameplate prior to attachment of nameplate to equipment.
- B. Nameplate lettering data shall be as follows:
 - Customer Equipment Tag No. _____
 - Owner's Representative Reference No. _____
 - Purchase Order No. _____
 - Manufacturer's Project No. _____
 - Manufacturer's Serial No. _____
 - Year Built _____
 - Mfg.'s Model No. _____
 - Design Data (i.e., design cfm, static pressures, fan rpm, motor amperage, horsepower, etc.)

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Electrical Data _____

Standard Mfg.'s Data _____

ETL Listing Number _____

- C. Provide permanently attached directional rotation arrow, painted to contrast with background, on items of rotating equipment.

1.6 GUARANTEES/WARRANTIES

- A. Include the following with technical data required with quotation:
1. Terms of manufacturer's standard warranty and costs (if any) associated therewith. A minimum warranty of 12 months from date of final acceptance is required. If final acceptance of unit does not occur within 6 months from date of shipment due to fault of the unit manufacturer, warranty shall be extended to account for delay and maintained at 12 months from date of final acceptance.
 2. Complete data on manufacturer's optional extended warranties and service contracts available including costs and details associated with each option. During warranty period the manufacturer shall provide labor and materials necessary to repair or replace, at his expense and without additional cost to VAMC, materials, equipment or workmanship in which defects may develop.
- B. Include the following with Purchase Order submittals:
1. Details of warranty or warranties purchased.
 2. Manufacturer's guarantee on equipment performance that is published in manufacturer's cataloged application and specification data.

1.7 DELIVERY, STORAGE AND HANDLING

- A. Seal fluid and air openings prior to shipment.
- B. Deliver products to site in protective containers, with factory installed shipping skids and lifting lugs.
- C. Coordinate maximum shipping split dimensions.
- D. Indicate VAMC Purchase order number and equipment number on the outside of each section delivered.

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PART 2 - PRODUCTS

2.1 AIR HANDLING UNIT

- A. Custom Outdoor Central Station Air Handling Unit shall be factory fabricated by an experienced manufacturer with all of the internal capabilities to factory fabricate, assemble, test, disassemble, ship to site and site verify/test the proper assembly and operation of the complete equipment module specified herein and shown on the design drawings/ equipment schedules and details.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Air Enterprises
 - 2. Buffalo Air
 - 3. Energy Labs

2.2 SCOPE OF WORK

- A. Provide suitable for outdoor/rooftop installation and mounting, with components, construction and capacity as specified.

2.3 GENERAL REQUIREMENTS

- A. Air handling unit, having capacity, arrangement and other characteristics shown on drawing schedules and/or data sheets, shall be provided and shall generally consist of factory-engineered modular sections with casings and components as specified further herein.
- B. Standard Construction
 - 1. The equipment shall be the manufacturer's standard construction wherever possible.
- C. All components requiring normal service and maintenance shall be identified and shall be easily accessible for service. The vendor shall specify clearances required around the equipment for normal service.
- D. Fans shall be rated in accordance with ASHRAE Standard 51/AMCA Standard 210-07 and shall be licensed to bear AMCA Seal. Coils shall be computer-selected based on ASHRAE calculation procedures or be rated in accordance with ARI Standard 410.
- E. Acoustic performance shall be as follows:
 - 1. Casing radiated sound pressure level at 3 feet from exterior of unit (including beneath the unit floor) shall not exceed 60 dBA.

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2. Relief Air Discharge sound pressure level measured 3 feet from exterior of unit shall not exceed 80 dBA. Airborne sound pressure level measured at supply duct connection to AHU casing/air tunnel/at smoke damper shall not exceed 95 dBA.
 3. Airborne sound pressure level measured at 3 feet from the outdoor air inlet air section/louvers shall not exceed 70 dBA. Provide rain resistant louvers. Sound attenuating inlet/weather hoods shall be provided if specified sound pressure levels are exceeded.
 4. Provide sound power levels in a minimum 7 octave bands for radiated noise at rated capacity.
 5. Test methods and facilities used to establish sound transmission loss values shall conform explicitly to the ASTM Designations E90 85 and E413 73.
 6. Test methods and facilities used to establish sound absorption values shall conform explicitly to the requirements of the ASTM Standard Test Method for Sound Absorption Coefficients by the Reverberation Method: ASTM C42384A and 795 83.
- F. Air handling units, accessories, and components shall be designed and constructed to meet the following seismic forces:
1. Occupancy Category = II
 2. Importance Factor IS = 1.0
 3. Design Spectral Response parameters (Short Periods): $S_{DS} = 0.171g$
 4. Design Spectral Response parameters (Long Periods): $S_{D1} = 0.374g$
 5. Seismic Design Category = A
 6. Site Class = D
- G. Include lights, electrical devices and wiring as specified further herein.
- H. Unless restricted by shipping and rigging requirements units shall be shipped factory-assembled and ready for mechanical and electrical connections. If units must be shipped in sections or disassembled sections, unit manufacturer shall furnish hardware and gasketing and include complete assembly and installation instructions. Arrange shipping splits to minimize number of sections and include number of

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sections along with bid. Equipment and materials shall be covered and protected against dirt, water, chemicals and damage during shipment.

2.4 UNIT CONSTRUCTION

- A. Unit shall employ aluminum material (panels, bases, supports, safing, etc.) to reduce overall unit weight and minimize facility maintenance requirements.
- B. Provide safing between internal components and unit casing to prevent air bypass. Safing material shall match unit interior. All seams or voids between safing, components and unit casing shall be caulked and sealed airtight.
- C. Provide hygienic unit design with interior suitable for washing down. The use of support members framed within the unit casing which will allow for trapping of debris between the supports and casing will not be allowed. Unit insulation must be completely encapsulated.
- D. Service Corridor/Equipment Access Areas
 - 1. Service Corridor shall extend entire length of unit, shall be full height of the unit and shall be per contract drawings.
 - 2. Corridor shall be of similar construction and insulation as the unit casing. Provide exterior doors, minimum (2) 36" wide x 72" high, with 12"x12" windows, at supply air discharge end of the corridor.
 - 3. Service corridor floors shall be 3/16-inch thick aluminum tread plate with welded seams to produce watertight floor system. The perimeter of the floor-plate shall have a 2" lip turned up and seam welded.
 - a. Underside of the floor plate shall be welded to the structural base frame to prevent any "oil-canning" or objectionable deflection.
 - b. Holes provided in service corridor floor for pipe/conduit, etc., electrical conduit/feeders to/from VFD's, etc.) shall be neatly cut, and exposed edges framed by structural angles for large openings, or by metallic sleeves welded in place for smaller openings.
 - c. Floor opening framing and sleeves shall extend up into the unit two inches and be fully seam welded to form a dam.

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- d. Service Corridor Floor insulation shall be similar to AHU air tunnel floor, walls and roof.
 - e. Maximum live load floor deflection shall not exceed lesser of $L/360$ and $1/2$ inch.
 - f. Service Corridor Floor Drains: Install floor drains within sections similar to AHU access sections. Locate drains in proximity to cooling coil chilled water piping connections, outdoor air plenum, heating hot water coil and humidifier.
- E. Heating within the service corridor will be hydronic unit heater (by Mechanical Contractor) with local thermostat to control unit heater fan and control valve operation. Refer to control diagrams/sequences of operation for additional information.
- F. Ventilation within the service corridor will be via supply duct taps from unit discharge supply duct manifolds into service corridor with local air terminal unit and associated temperature controls (by Mechanical Contractor). Air Terminal Unit (VAV Box) shall be controlled via local thermostat within service corridors. Refer to control diagrams/sequences of operation for additional information.
- G. Lighting fixtures shall be as specified herein.
- H. Base Frame
- 1. Each unit or shipping section shall be mounted on an insulated, one piece welded frame, fabricated from aluminum shapes. Sufficient internal framing and stiffeners shall be provided, along with properly located lifting lugs to allow for the rigging and handling of the unit.
 - 2. Aluminum bases do not require painting.
Minimum base height, heating coil mounting height, humidifier mounting height and cooling coil mounting height up off floor of AHU air tunnel shall provide sufficient clearance for, drain pan trap seals and cooling coil condensate drain trap seal without disturbing the finished service corridor floors (assuming air handling unit air tunnel floor matches the line of the floor of the service corridor. Coordinate details of air handling unit drain pans to discharge into the service corridor floor drains above the line of the floor.

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3. The unit base shall be provided with sloped sumps in areas as indicated on the drawings. Sumps to be welded and guaranteed waterproof to serve as a drain pan to prevent building water damage from the unit. Sump to be double-sloped (min. $\frac{1}{4}$ " per foot) towards units drains to positively remove condensate from the unit.
4. The base floor shall be minimum $\frac{3}{16}$ " thick aluminum plate welded at all joints and to structural members. Floor material shall have safety-tread surface. The base floor shall be designed for a minimum live load of 100 pounds per square foot throughout the unit. The base floor is to be supported with adequate stiffening members to prevent oil canning. Caulking, gaskets and mechanical fasteners to guarantee seals and water tightness of joints will not be acceptable.
5. The perimeter support members shall be a minimum of 6" structural member properly sized to support all major components and the housing during rigging, handling and operation of the unit.
6. The underneath side of the base pan and base perimeter shall be insulated with minimum 2" thick 1.5-pcf high density polyisocyanurate foam insulation to form a vapor barrier. Vapor barrier is then protected by a 0.040" thick aluminum sheet attached to the bottom of the base.
7. Each section of the unit base shall contain a minimum 1" NPT drain to facilitate system washdown, maintenance and condensate removal. Areas in the base where potential standing water cannot be removed through drains or weep holes are not acceptable. Clean out drains shall be provided with removable caps of non-corrosive material.
8. All equipment within air handling unit shall be provided with a minimum 2" high base to raise equipment off unit floor for housekeeping.
9. Supply air openings to be framed with 2" high water dam continuously welded to the pan to allow proper duct connections and to prevent moisture from entering the openings. Framed openings shall be provided with removable aluminum or 304

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stainless steel grating designed and fabricated for a live load of 100 pounds per square foot.

10. All unit base service openings shall be framed with a minimum 2" high water dam continuously welded to the floor. All pipe and electric conduit chases with openings to building or elements shall be covered with thin gage aluminum or 304 stainless steel. Penetrations by contractors shall be sealed by the respective contractor.
11. Fastening to floor plate or joining of unit sections to be accomplished by bolting through gasketed joints above the floor line or continuously welding. Fasteners which penetrate base floor plate are not acceptable.
12. Unit to be provided with properly located permanent lifting plates or removable lifting lugs for each section to adequately allow rigging of the unit sections in place.

I. Casing

1. The unit casing shall be double-wall, insulated sandwich construction or insulated panels supported by internal channel framing designed to limit panel deflections to 1/200th of any span at the design fan total pressure plus any snow and wind loads. Floor panels shall have additional internal structural channels for walk-on duty and full support of components.
2. Casing (interior and exterior) shall be 0.04" thick aluminum sheets. Aluminum sheets shall be of aluminum alloy 3003-H14 and conform to ASTM B209. Interior panels shall be solid, smooth aluminum sheets. In all cases, panel sheet thickness shall be increased where necessary to meet the deflection criteria cited above. All dissimilar metals shall be electrically and thermally isolated to prevent galvanic action.
3. The insulation material (between the inner and outer sheets) shall consist of 3 lb./CF density polyisocyanurate foam with a thickness to meet a minimum R value of 12. Insulation shall conform to ASTM E84, NFPA 255 and UL 723 and shall meet local code requirements. Insulation thickness or density shall be

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increased as required to prevent condensation as required in paragraph below.

4. Provide manufacturer's standard thermal break throughout entire unit casing between supports and panel sheets. Thermal break shall prevent condensation at design operating conditions and an outdoor condition of 99F dry bulb temperature and 77F wet bulb temperature. Thermal break joint construction shall consist of ½" structural epoxy bridge creating a true "no-thru" metal construction. Screws thru gaskets to adjoin casings is not acceptable.
5. The entire custom AHU air tunnel enclosure shall be constructed to maintain a maximum air leakage rate not in excess of 1 percent of total AHU air flow or 30 cfm whichever is greater at 125% of design internal negative or positive static pressure. Worst case static pressure shall apply for complete positive or negative section.
6. Ductwork systems and sections within the AHU for supply and return shall be tested in accordance with specified and scheduled duct leakage requirements. All ductwork penetrations through unit enclosure shall be provided with framed openings of size and arrangement as indicated on drawing. Openings to be provided with flanged duct connections of same material as casing interior extending a minimum of 4" from surface of unit casing.
7. All threaded fasteners and mounting hardware shall be stainless steel. Aluminum closed rivets may be used with units with aluminum framing.
8. Extend piping and conduit through unit casing as specified further herein. Provide unions or flanges on extended piping to allow for coil removal. Cap or plug open ends of piping and conduit before shipping. Pipe and conduit penetrations through the unit casings shall be provided by the unit manufacturer and be properly sealed prior to leaving the factory. Penetrations sealed by caulking around extension are not acceptable.
9. Provide minimum 24" wide access doors for access to all internal components. Access doors shall be installed to open against the

greatest pressure relative to air pressure on each side of access door.

- a. Access doors shall be of the same construction as panels described above.
 - b. The access doors shall incorporate two continuous separate gasket seals around the entire periphery of the door. Gasket material shall be UV-resistant, closed cell neoprene; gaskets shall be attached by adhesive and not mechanically held in place.
 - c. Each access door shall contain a thermopane safety glass window (min. 10" square).
 - d. Each access door shall be mounted with a corrosion-resistant continuous piano hinge and shall have a least two (2) non-corrosive handles operable from either side.
10. Access doors shall be provided where indicated on drawings and as specified herein. Provide removable/replaceable panels where required to remove fans and coils. Panels shall be designed and constructed with suitable framing, gasketing and fastening devices such that removal and replacement may be accomplished without disturbing adjacent panels. Air tight integrity shall be maintained.
 11. Provide safing between internal components and unit casing to prevent air bypass. Safing shall be of same material as casing of internal component, of suitable gauge and properly braced and reinforced as required. Voids between safing, components and unit casing shall be caulked and sealed airtight. Provide 304 stainless steel safing for cooling coils and humidifiers.
 12. Provide Vent-Lok instrument test ports before and after sections which have changes in pressure, temperature, or humidity. Ports shall be gasketed threaded sleeves, caulked and sealed, and provided with threaded cap.
 13. Sheet metal seams shall be caulked watertight. Exterior seams shall receive additional caulking as required. Caulks and sealants shall be FDA-approved, silicon-based, non-drying type

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suitable for aluminum surfaces. All internal joints and seams shall be caulked.

14. Roof shall be sloped a minimum of 1/4 inch per foot for drainage. The entire roofing system shall be a polymer membrane permanently bonded to the unit roof. Membrane to be minimum 0.045" thick. Standing seam roofing system will not be acceptable. Roof system shall be designed for Design Snow Load of 21 lbs./square feet. Pitch of roof shall be in the long dimension of the AHU towards supply plenum discharge end/existing building wall that extends up to the fifth floor above. See plans for additional information.
15. Exterior mounted units with sloped roof assemblies shall include gutters and downspout systems sized adequately for the overall size, pitch, quantity and direction of slope for the unit roof. Rainwater shall be directed away from access doors and utility penetration locations.

J. Floor

1. The floor shall be constructed of 0.125" (minimum) thick safety-tread aluminum top sheet and 0.04" thick aluminum bottom sheet insulated similar to unit walls and roof. The floor shall be supported by the internal framing of the base. Insulation on top of floor is not acceptable. Floor in outdoor air intake, cooling coil and humidifier sections shall have stainless steel drain pan mounted on top of floor. As an alternate, the floor shall be welded construction with minimum 0.125" thick Type 304 stainless steel designed to act as a drain pan. Floor shall be designed for on-board maintenance. Refer to cooling coil and humidifier sections for drain pan details. Provide removable walk-on grating for drain pans that must be walked on for access to coils, components, damper actuators, etc.
2. Provide floor drains in service corridor sections as indicated on AHU detail drawing. Pipe each floor drain without trap down through unit base. Floor drain piping shall extend to nearest roof drain. Piping shall be Type DWV hard-drawn seamless copper tubing, ASTM B306 with copper solder fitting joints.

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K. Access Doors

1. Hinged access doors shall be provided on one side in sections requiring regular inspection or maintenance (coils, dampers, humidifiers, etc.). Removable hatches or panels shall be provided in addition to access doors to facilitate removal of coils, fans or other equipment as shown on drawings.
2. Doors shall be similar in design and construction to the exterior wall panels. Each door shall be mounted with a continuous stainless steel piano type hinge or approved equal in a heavy duty extruded aluminum frame. Doors shall open against static pressure.
3. Inside and outside chrome-plated door handles equipped with 2 or 3 point latching mechanisms and extruded rubber gasketing shall be used to close and seal the doors. Seals shall be replaceable. Doors shall be designed for tight closing to achieve the leak classification specified. Means for locking doors shall be provided.
4. Doors shall be of the maximum height that the unit will accommodate (up to 60"). Doors shall be provided with a minimum 12"x12" or 12" diameter view port of double thickness wire reinforced or tempered glass mounted in a gasketed frame.
5. For filter sections and other areas requiring regular access by maintenance personnel, the minimum door width shall be 24 inches. The minimum door width for fan access shall be 30 inches. The minimum door width shall be 18" for other areas. Refer to AHU configuration drawing for additional requirements.

2.5 OUTDOOR AIR INTAKE AND DISCHARGE PLENUM SECTIONS

- A. Sections shall be provided with dampers as indicated by AHU configuration sketch, equipment schedule and/or datasheet.
- B. Provide access doors as indicated.
- C. OA intake plenum shall include minimum and maximum OA intake louvers, combination damper/airflow measuring stations and raised floor with drain pan. AHU openings/louver assembly frames shall be sealed air and water-tight and integrated into casing to prevent moisture and debris

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from entering the insulation space between inner and outer skin of the AHU walls.

- D. Supply air discharge opening for AHU with flanged connection collar extended through unit opening and coordinated for sheet metal ductwork connection. AHU openings and collar connections shall be sealed air and water-tight and integrated into casing design to prevent moisture and debris from entering the insulation space between inner and outer skin of the AHU walls. The AHU supply air discharge shall include smoke isolation damper mounted within the supply air discharge indicated on the AHU detail drawing.

2.6 AHU SUPPLY AIR FANS

A. General

1. Each centrifugal supply air fan shall be plenum style, SWSI, furnished completely assembled and fitted with an electric motor, direct drive, inlet guard and adjustable vibration isolator base. Fans shall be sized to the performance requirements specified and shall be rated and certified in accordance with latest editions of ASHRAE and AMCA test codes and guaranteed by the manufacturer to deliver at the rated level. Fans shall be statically and dynamically balanced at the factory. Fan RPM shall not exceed 90% of the maximum allowable rpm for the class construction selected.
2. Fans shall be capable of automated turndown through the design range from maximum to minimum conditions without stall, surge or increased vibration.
3. First critical speed shall be at least 25 percent higher than anticipated maximum operating rpm.
4. Provide an internal structural rail suitable for attachment of block and tackle. The rail shall facilitate lifting and transporting motor to the unit exterior. Rail shall be included in both the AHU fan section and within both sides of the service corridor outside the fan section extending to the closest service corridor exit door. Rails shall also be extended to allow for removal/replacement of AHU coil/humidifier components.

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B. Motors shall be 1750 RPM, 460V/3ph/60Hz as per the following:

1. Motor shall be premium efficient, TEFC enclosure.
2. Motor shall be of HP listed on schedule; selected to provide adequate torque throughout entire range of fan operation and not exceed nameplate HP when fan operates at synchronous motor speed.
3. Motor shall be designed for continuous duty operation, NEMA Design B with class F insulation.
4. The motor shall be suitable for operating with variable frequency drives without undue noise, vibration or deterioration of reliability and life.
5. Motors shall be "Inverter Ready" per NEMA Std. MG1 part 31.4.4.2 and labeled as such.
6. Provide stainless steel nameplate indicating the following:
 - a) NEMA efficiency index nominal efficient (MB1-12.53B0).
 - b) AFBMA bearing numbers.
 - c) Lubrication instructions.

C. Base

1. The fan and motor shall be mounted on a structural steel base isolated from the unit base with spring type vibration isolators. Isolators shall be selected in accordance with fan weight distribution such that fan rests level. Unit isolation efficiency: at least 90 percent. Provide thrust restraints as required. Provide concrete inertia base/filling with concrete at project site after final mounting/assembly as required per specifications. Include concrete weight in final operating weights submitted for AHU as required.
2. Fan discharge shall be connected to casing with a flexible neoprene connector. Duct connection shall be UL-listed and fire rated.

D. Wheels

1. Blades shall be of the non-overloading, double thickness airfoil type staggered on each side of the center plate. The wheel shall be keyed to the shaft and the key secured with setscrews

E. Cleaning & Painting

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1. The completed assembly (entire fan, base, and wheels) shall be cleaned in accordance with the Steel Structures Painting Council (SSPC) SP-1, SP-2 and SP-3 to produce a rust and scale free surface. The interior and exterior surfaces shall then be primed and finished in accordance with manufacturer's standard specification. Aluminum wheels and components do not require painting.

F. Shafts and Hubs

1. The fan shaft shall be fabricated from solid AISI hot rolled steel which is accurately turned, ground, polished and ring gauged for accuracy.
2. Hubs shall be cast iron, straight bored, keyed and set screwed for positive attachment.

G. Bearings and Drive

1. Bearings shall be foot mounted on a structural steel frame integral with the fan base and housing. The bearings shall have a minimum ABMA L-50 life of 1,000,000 hours (equivalent to L-10 life of 200,000 hours) at maximum operating conditions. Copper lubrication lines shall be provided from all bearings (and any other lubrication points) to a common area outside the air handling unit air tunnel casing. All lubrication lines shall be labeled.
2. The fan drive guard and fan inlet guard shall be in accordance with OSHA requirements. The drive guard shall be a two-piece design split along the shaft centerlines such that the top half is easily removed and reinstalled. Designs requiring the use of hand tools to open the guard or resulting in loose fasteners are not acceptable. The guard shall contain tachometer openings for motor and fan sheaves as necessary for fan type.

2.7 COIL SECTIONS

A. General

1. Coils shall be removable without disturbing adjacent coils or equipment. Coils shall be rated by the manufacturer in accordance with ARI Standard 410 and shall be tested under water using 325 psig compressed air. Connections shall be copper with

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union or flanged ends extending through the unit casing. Unions shall be wrought copper with solder joint ends and copper seats. All water coils shall have top return connections to ensure proper venting. Drain and vent (or vacuum breaker for steam coils) connections shall be provided. All casing penetrations shall be sealed airtight. All coil headers shall be fabricated from minimum 0.060" wall seamless copper pipe and shall be brazed to the coil tube connections.

2. Coils shall be a maximum 10 feet wide and 4 feet high.
3. Piping for all coils shall be internally run and piped through AHU air tunnel casing walls by AHU manufacturer. All piping penetrations through AHU casing shall be factory gasketed, sealed air and water tight and pipe shall be capped.
4. Mount heating coils and cooling coils as high as possible within the AHU to ensure the proper height for steam trap and cooling coil condensate drainage trap assemblies (above finished floor line. Provide supports to mount coil assemblies up and provide safing within AHU as required to allow elevated coil mounting.

B. Water Coils:

1. Water coils shall be manufactured from 5/8" O.D. x 0.035" wall seamless copper tubing mechanically expanded and bonded to 0.0055" minimum thick aluminum fins with a maximum spacing of 10 fins per inch. Coil air pressure drop shall not exceed 1.2" w.g..
2. Coil casings shall be fabricated from 16 gauge type 304 stainless steel and shall incorporate intermediate tube supports for coils over 4'-0" long.
3. Coil banks shall have a maximum depth of 10 rows. If more than 10 rows are required, the coil shall be split into two sections with an access door between the sections.

C. Chilled Water Coils.

1. Chilled water coils shall be manufactured from 5/8" O.D. x 0.035" wall seamless copper tubing mechanically expanded and bonded to 0.0095" minimum thick copper fins with a maximum spacing of 10

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fins per inch. Coil air pressure drop shall not exceed 1.2" w.g. when fully wet.

2. Coil casings shall be fabricated from 16 gauge type 304 stainless steel and shall incorporate intermediate tube supports for coils over 4'-0" long.
3. Coil banks shall have a maximum depth of 10 rows. If more than 10 rows are required, the coil shall be split into two sections with an access door between the sections.
4. Condensate pans shall extend the entire length of the coil including the header and return bends, as well as a minimum 12" downstream from the coil and 3" upstream of coil. Pan shall be sloped to promote positive drainage. Pan shall be fabricated from all welded, type 304 stainless steel and shall have a minimum depth of 3". Insulation similar to the unit casing shall be provided under drain pan. Pans shall have one drain connection sized for maximum condensate flow, but no less than 1-1/4" diameter. Pans shall have extension upstream of cooling coils or provide separate small lip/drain pan with separate drain.
5. An intermediate type 304 stainless steel drip pan shall be supplied with coils over 48" high and shall be factory piped to the main condensate pan. No insulation is required on intermediate drain pans. Piping shall be Type DWV hard-drawn seamless copper tubing, ASTM B306 with copper solder joint fittings. Pans shall have extension upstream of cooling coils or provide separate small lip/drain pan with separate drain extended down to lower drain pans/raised floor drain pan.
6. The design coil face area shall be sized to minimize carryover of condensate into the air stream. The maximum design face velocity for coils conditioning all outside air shall be 450 fpm. Systems that generally have 20% or less outside air shall be designed for a maximum 500 fpm face velocity.

2.8 FILTER SECTIONS

A. General

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1. Each unit shall be supplied with pre-filters, after filters and final filters installed in frames designed and arranged for servicing through an access door located on the inlet side of the filter. Filter efficiency shall be as specified herein and shall comply with the minimum average efficiency as determined by the appropriate ASHRAE or IEST test method.
 2. Filters shall be of fire resistant construction and shall comply with UL Class 2 requirements and shall be suitable for use in airstreams up to 190°F and 100% RH.
 3. Filters shall be standard manufacturer's sizes.
 4. Provide front face loading type housings.
 5. Each filter section shall be provided with factory installed copper differential pressure ports across each filter extended to the outside of the unit housing.
- B. Pre-filters (Pre-Filter 1)
1. Pre-filters shall be 2" thick (minimum) throwaway type with a minimum efficiency rating of MERV 8 as measured by the ASHRAE Standard Test Method (equivalent to 30 to 35% dust spot efficiency and greater than 90% Arrestance). The filter media shall be pleated, self-extinguishing non-woven cotton with trace polyester fibers. Maximum design velocity shall be 500 FPM. The media backer shall be 24 gauge, 1 inch square electro-plated, steel wire bonded to the media and secured in a heavy duty beverage board frame. Refer to schedule drawing for additional requirements.
 2. Filter size shall be nominal 24" x 24" and/or 24" x 12". Refer to AHU configuration drawing for additional information. Consistent / all 24" x 24" filters are the preferred basis of design.
- C. After Filters (Secondary/Pre-Filter 2)
1. After filters shall consist of a replaceable factory assembled cartridge-type element, incorporating a fiber glass medium and a corrosion resistant frame. Maximum design velocity shall be 500 FPM. Minimum efficiency rating shall be MERV 11 (equivalent to 60-65% dust spot efficiency and greater than 95% Arrestance) as measured by the ASHRAE Standard Test Method. The complete final

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filter assembly including the frame shall not exceed 12" in depth. Refer to schedule drawing for additional requirements.

2. After filter size shall be nominal 24" x 24" and/or 24" x 12". Refer to AHU configuration drawing for additional information. Consistent / all 24" x 24" filters are the preferred basis of design.

D. Final Filters

1. Final Filters shall be mounted after the discharge of the supply fans within the AHU tunnel and shall be MERV 14 filters (equivalent to 90-95% dust spot efficiency and greater than 98% Arrestance) as measured by the ASHRAE Standard Test Method. Refer to schedule drawing for additional requirements.
2. Final filter size shall be nominal 24" x 24" and/or 24" x 12". Refer to AHU configuration drawing for additional information. Consistent / all 24" x 24" filters are the preferred basis of design.

E. Holding Frames for Pre-filters, After-filters and Final Filters

1. Filters shall be installed in holding frames constructed of galvanized steel with minimum $\frac{3}{4}$ inch sealing flange and polyurethane foam gasket. Spaces between frames, casing, roofing and flooring shall be caulked, gasketed and sealed airtight. The filters shall be secured in the holding frame with gasketing and, where required, stainless steel retaining clips.

F. Air Purification-Filtration System (UV system). Refer to AHU configuration drawing, equipment schedules and details for additional information.

2.9 DAMPERS

A. General

1. Dampers shall be provided as indicated on the drawings.
2. Damper assemblies shall consist of airfoil type blades set in an extruded hat channel frame with mounting flanges on both sides of the frame. Aluminum construction shall be provided for outdoor air dampers. Galvanized construction may be used for other applications.

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3. Dampers shall be low leakage design and shall be able to close against dead head pressure of the associated fan system without structural failure/deflection, etc. Damper blades shall be arranged in vertical or horizontal arrangement to help mitigate deflection/warping of blades/leakage. Leakage through a representative 48" x 48" damper at 4" W.G. pressure differential shall not exceed 7 CFM per square foot.
4. Dampers shall have an extended control shaft for installation of damper operator.
5. Maximum size for single section: 48" wide by 72" high. Split damper sections into multiple units accordingly. Ensure the overall assembly complies with dead head close off pressure requirements specified herein and for each respective fan per equipment schedules. Provide separate damper actuators and end switches as required. Coordinate damper section quantities and control points/airflow monitoring stations/wiring requirements with BAS contractor.
6. Final damper sizes, actuator quantities and actuator placement must be coordinated for accessibility and maintenance requirements. For example, the minimum and maximum Outdoor air intake damper sizes and actuator locations must also be coordinated within outdoor air intake plenum and mounted on louver extension duct plenum assemblies (full size/face of louvers). Refer to AHU detail drawing and combination damper/airflow measuring station schedule for additional requirements. Coordinate clearance, mounting requirements and proper blade arrangement (in general/unless noted otherwise parallel blade for isolation/smoke dampers, opposed blade for mixing/modulating dampers).

B. Blades

1. Blades shall be of the airfoil type with integral structural reinforcing running the full length of each blade. Blade edges shall be provided with extruded vinyl seals secured in slots (in both blades and frame) without the use of cement. Blades shall

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be no more than 6" wide. Opposed blade design shall be used for OA intake and modulating applications.

C. Smoke Dampers

1. Where dampers are to be used as part of a smoke purge/control system, provide dampers that meet UL 555S Leakage Class I. Smoke dampers to be parallel blade. Refer to PEM detail drawing, control diagrams and sequences of operation for additional requirements. Refer to specifications section 23 31 00 for additional smoke damper requirements and specification section 28 31 00 for smoke detector requirements.

D. Fire Dampers

1. All fire dampers shall be dynamic dampers. Where fire dampers are required within ducts operating as part of a smoke purge/control system, provide 285 deg F fusible link. Refer to specification section 23 31 00 for additional fire damper requirements.

2.10 HUMIDIFIER SECTION

- A. Provide humidifiers of the following type and of size and capacity as indicated on the data sheets/schedule drawings.
- B. All humidifier piping connections shall be internally run within air tunnel and piped through unit casing into the AHU service corridor. Pipe penetrations shall be factory gasketed and pipe shall be sealed and capped.
- C. Humidifier: Steam injection panel type, consisting of supply and condensate headers connected with a bank of vertical steam dispersion tubes. Each tube shall have 2 rows of diametrically opposed nozzles. Humidifier shall provide absorption characteristics that preclude water accumulation on unit surfaces beyond scheduled vapor trail distance.
- D. Tubes and header shall be contained in a stainless steel casing suitable for flanged air handling unit mounting.
- E. Tubes and headers shall be Type 316 stainless steel.
- F. Control valve shall be normally closed with a minimum of 7 psi spring range. Maximum flow through wide-open valve shall not exceed 133 percent of (1.33 times) scheduled flow rate and have a minimum Turn Down Ratio of 30 to 1 for ½ inch and ¾ inch valves and 60 to 1 for

larger valves. Valves shall be designed for ANSI 125/150 pound service and ANSI/FCI Class IV (or higher) leakage rating. Valves shall be sized for humidification range as required for AHU performance from 30% to 100% airflow capacity at design humidification outdoor air conditions. Provide 1/3 - 2/3, dual control valve arrangement if single control valve cannot adequately satisfy capacity control requirements.

- G. A blocking valve shall be provided.
- H. Provide individual F&T Traps to drain the header and the steam jacket manifold (where required/for jacketed style humidifiers). Run individual condensate lines directly to the outside. Refer to details and humidifier manufacturer piping diagrams for condensate drainage from dispersion panel style humidifiers (atmospheric pressure steam condensate).
- I. Provide electronic/analog modulating control valve actuator with position feedback
- J. Provide 316 stainless steel drain pan in humidifier section. Drain pan shall meet requirements as specified for the cooling coil section.
- K. The humidifier shall be designed to minimize length of moisture plume to permit full vaporization without condensation of moisture on any internal surfaces. The air handling unit manufacturer shall follow the humidifier manufacturer's recommendations for minimum upstream and downstream clearances and mounting of high limit humidity sensor a minimum of 10 feet downstream of the humidifier dispersion tube assembly within the AHU discharge plenum.
- L. The air handling unit/humidifier manufacturer shall guarantee system performance including maximum plume length, and submit supporting calculations.
- M. Mount steam humidifier dispersion panel as high as possible within AHU air tunnel to allow for proper steam condensate trap height and installation of condensate traps above AHU service corridor floor line. Provide 316 stainless steel safing or aluminum safing matching interior AHU air tunnel panels all around humidifier dispersion panel to ensure air does not bypass humidifier dispersion tube assembly.

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2.11 BAS/CONTROL REQUIREMENTS

A. General

1. AHU is intended to be a factory-wired piece of equipment with single point power connection. All building automation system controls shall be field installed by BAS/Controls Contractor.
2. Coordinate location and wiring of all controls components to AHU mounted control panels. Ensure complete BACNET integration and mapping of all AHU measuring, monitoring, control and alarm points, allowing for remote control and monitoring of all AHU functions via existing site central BAS controls system.

B. AHU Manufacturer and Controls Contractor Scope and Coordination

1. Building automation systems/controls shall be fully coordinated between AHU manufacturer, component manufacturers and project controls contractor. Control devices, hardware, actuators, controllers, etc. shall be coordinated and supplied by controls contractor unless the specific piece of equipment/component is specified to include its own controls (e.g. airflow monitoring stations with integral damper assemblies, etc.)
2. AHU manufacturer and controls contractor shall work carefully with all suppliers to ensure that the devices indicated on control diagrams and in sequences of operation are installed within the AHU. Installation of devices and hardware by Controls contractor for shall follow AHU manufacturer protocols carefully.

2.12 ELECTRICAL REQUIREMENTS

A. General

1. The AHU is intended to be a factory-wired piece of equipment with single point power connection (emergency power for entire AHU) and all electrical power equipment, components, devices, light fixtures, switches, receptacles, etc. in place and tested prior to shipment to project site.
2. The unit shall include all required panelboards, disconnect switches, step-down transformers, motors, variable frequency drives, smoke dampers, smoke detectors, lighting, GFCI receptacles, switches, etc.

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3. Components and wiring methods shall comply with applicable and current standards of NFPA, IEEE, ANSI, NEMA and Underwriters Laboratories, Inc.
4. Complete electrical installation shall conform to requirements of current edition of the National Electrical Code, NFPA, OSHA and state codes, local codes or regulations having jurisdiction.
5. Factory wiring shall be enclosed in rigid aluminum conduit or EMT. 480-volt wiring shall be type THHN/THWN 600 V insulated wire. 120-volt wiring shall be a minimum No. 12 AWG, Type THHN/THWN insulated wire. All wiring to be stranded copper. Provide flexible liquid tight connections to fan and pump motors.
6. All wiring shall be run with a green insulated ground wire sized per the NEC. Minimum conduit size shall be 3/4".
7. All materials and installation methods shall be in compliance with the latest edition of NEC and the completed installations shall be factory tested. Components shall be labeled and wires numbered.
8. Junction boxes and covers where used in dry locations shall be galvanized steel. Junction boxes and covers where used in damp or wet locations shall be corrosion resistant, weatherproof, cast metal with threaded hubs and neoprene gasketing.
9. Fan variable speed drives shall be provided by AHU manufacturer in accordance with specification section 26 29 11, MOTOR CONTROLLERS and will be mounted within the new penthouse equipment module. Coordinate each VFD enclosure type, configuration, size, mounting location within AHU as required to ensure proper access and to reduce exposure to heat/moisture within access areas/service corridor. Required Code clearances must be maintained.

B. Service Lighting and Utility Outlets

1. Custom AHU air tunnel, intake/relief/discharge plenums, AHU component access sections, fan and filter sections shall each be equipped with marine type light fixtures with a 100 watt equivalent, 120V compact fluorescent fixture. Provide low temperature ballast. Refer to AHU detail drawing for additional

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requirements. Service corridor/access area lighting shall be sealed 1x4 fluorescent mechanical equipment room light fixtures in accordance with specification section 26 51 000 suspended within service corridor/equip access areas. Carefully coordinate service corridor light fixture quantities and locations to provide adequate light levels in accordance with/similar to VAMC minimum guidelines for mechanical equipment/electrical rooms: 40 Foot Candles.

2. All AHU Internal Air Tunnel lighting shall be factory wired and controlled by light switches at the access door of each section end of the unit. Switch shall be wired to include a timer function, turning off lights after a set/programmable duration of time.
3. AHU service corridor lighting shall be factory wired and controlled by a light switch located just inside the main entry doors. Provide four, unswitched GFCI type utility outlets. Locate two each at 1/3 and 2/3 length of the AHU on air tunnel exterior wall on both access sides of the AHU air tunnel. Coordinate location of outlets with AHU piping, access doors, etc. Mount in accessible locations.
4. Provide two additional, unswitched GFCI type utility outlets within the AHU service corridor/access areas. Locate one adjacent to return relief air plenum, locate one adjacent to the main entry doors. Light switches and receptacles shall be industrial specification grade as manufactured by Hubbell, Arrow-Hart, Bryant or Pass & Seymour.
5. For units shipped in sections, light fixtures, switches, receptacles and any other 120V devices shall be factory wired to junction boxes with wiring coiled and tagged to facilitate field connection between sections and to terminal box.
6. Provide weatherproof covers for all receptacles and switches.
7. Provide appropriate weather-tight NEMA enclosures for all electrical and controls devices included with the AHU.

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C. Motors

1. Motor specification, including efficiency, shall be in accordance with Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC.
2. Design for operation with AC variable frequency drive controllers (VFD) for speed control application. Motor shall comply with all sections of NEMA MG-1 Part 31 compliant with 1600-volt insulation.
3. Motors rated less than 7-1/2 hp down to and including 1 hp (for which efficiency is not listed in EL-292) shall be of the premium efficiency type and the nominal efficiency percentage shall be the highest available from the acceptable motor manufacturers listed in EL-292.

D. Fan Motor Disconnect Switch

1. Provide factory-mounted and wired, lockable, fused disconnect switches for fans. Switch shall meet requirements of NFPA, local codes and have components that are UL-listed and labeled (Including an Arc Flash warning label.) Switch shall be mounted on access door side of fan section of the AHU.
2. Procedurally, these switches should not be opened while under load. Disconnect switches local to motors shall include an auxiliary contact that works in coordination with the disconnect switch handle so when the disconnect switch handle operates to open, the auxiliary contact will open and signal the VFD before the operator actually breaks the power.

E. Safety

1. Accessible external surfaces of equipment shall not exceed 60 degrees C (140 degrees F).
2. Products containing insulating liquids with polychlorinated biphenols (PCB) shall not be used.
3. Live parts shall be incapable of being inadvertently touched or approached nearer than a safe distance by a person.
4. Control voltage shall not exceed 120 Volts AC or 24 Volts DC. Where residual voltage may exist after disconnection of power source, provide warning sign.

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5. Areas of panel where voltages above 120 VAC are present shall be clearly identified using warning labels.
6. Grounding and Bonding
 - a. Run insulated grounding conductor in electrical conduits and cables. Exposed noncurrent-carrying metal parts of equipment package shall be bonded and connected to grounding pad or terminal (for connection of Purchaser's ground wire). Bonding of flexible metal conduit over 3 feet using external copper bonding jumper, sized in accordance with NEC Article 250. Include ground wires within cable assemblies and connect at both ends to provide continuous fault current path source quality control.
7. Lightning Protection
 - a. Coordinate as required by specification 26 41 00, FACILITY LIGHTNING PROTECTION. Attachments to exterior of AHU shall be in accordance with AHU manufacturer details, including proper sealants to prevent moisture leakage into space of wall panels/insulation within wall panels. AHU manufacturer to provide details to installing contractor and coordinate with electrical contractor.

PART 3 - EXECUTION

3.1 UNIT TESTING AND INSPECTION

A. General

1. Manufacturer shall be responsible for engineering, design, fabrication, inspection and testing, preparation for shipment, delivery and furnishing necessary documentation.
2. Owner's Representative reserves the right to inspect and witness testing of purchased equipment at any time. Owner's Representative shall have access to manufacturer's facility to inspect work in progress and witness factory testing. Access shall include areas involved in production of equipment and materials and subassemblies designated for that equipment. Access shall also be provided to such areas required for Owner's Representative to determine that proper fabrication and quality control procedures are being adhered to. Inspection and

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witnessing Factory Acceptance Testing (FAT) by Owner's Representative does not relieve manufacturer of his contractual obligations under terms of the Purchase order.

3. The complete unit shall be factory tested as an assembly to ensure compliance with this specification.
4. The manufacturer shall notify Owner's Representative and Engineer a minimum four weeks prior to the scheduled Factory Acceptance Testing. Owner's Representative will inform the manufacturer if project design team representative and Owner representative will witness the FAT. Manufacturer shall coordinate FAT timeframe with both the Government and A/E.
5. Equipment shall not be shipped from the factory to the project site until Owner's Representative/VAMC COR has given their written approval.

B. Factory Tests and Factory Acceptance Testing (FAT)

1. Manufacturer shall submit test procedures to Owner's Representative for approval at least 4 weeks prior to scheduled tests. Manufacturer shall clearly list all tests planned to be carried out prior to the owner-witnessed tests and exactly what tests would be witnessed by owner representatives. Owner reserves the right to request incorporation of any and all tests herein to be witnessed during factory visit. Final list of witnessed tests shall be agreed upon prior to arrangement of FAT and signed off on by Owner/VAMC COR. Tests not witnessed shall be completed prior to FAT and results of testing and any corrective actions taken included in report to Owner's Representative for sign-off prior to shipment to project site.
2. Tests shall display scheduled performance characteristics, using certified testing instruments provided by the manufacturer.
3. Vibration Test: The unit fans shall be operated at the design RPM with the final/actual variable frequency drives associated with each fan. A complete vibration spectrum shall be conducted. Such tests must be performed on a completely assembled unit including all components. Unit manufacturer shall demonstrate compliance with the fan manufacturer's recommended vibration

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tolerances. Fans designated for variable speed operation shall be tested and balanced for motor speeds from design maximum down to 20% in at least 20 percent increments. Vibration analysis to be performed by CVI/MISTRAS (OR APPROVED EQUAL).

Parameter (Order of 1x RPM)	Units	Vibration Level
Overall*	IPS (Peak)	0.2
Sub. to 1.5X RPM	IPS (Peak)	0.2
1.5 to 4.5X RPM	IPS (Peak)	0.15
4.5 to 20.5X RPM	IPS (Peak)	0.1
20.5 to 40.5x RPM	IPS (Peak)	0.11
40.5 to 70.5X RPM	IPS (Peak)	0.1
1 to 20 kHz	RMS Acceleration (G's)	1.5
Time Wave Form	G's	No Impacting

4. Coil Pressure Test: The heating and cooling coils shall be tested per specified requirements. Any other piping included with the air handling units shall be pressure tested in accordance with the requirements of specifications.
5. Electrical Function Test: The entire electrical system shall be functionally checked including disconnect switches, panel boards, transformers, motors, variable frequency drives, lights, utility outlets, switches, unit heaters, etc., for proper operation.
6. Casing Deflection Test: Casing shall be checked for maximum deflection at design operating pressures.
7. Leakage Test: The assembled unit(s) shall be factory tested for air leakage within the custom air handling unit air tunnel and separately for the service corridor. This test shall demonstrate that the leakage requirements specified for the casing are met.
7. Fan Performance Test: Test fan performance at maximum and minimum design CFM and static pressures in accordance with submitted fan curves. Test per AMCA field test procedure acceptance criteria as per AMCA standard. Test and document

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temperature rise at fan section inlet and outlet during fan performance testing.

8. Acoustical Performance Tests: Confirm performance as specified herein. Measure and document acoustic performance and make necessary adjustments as specified.
9. All measurements shall be performed with calibrated instruments and documented.
10. Manufacturer shall provide copies of all factory test reports, including vibration and leakage testing.

C. Field Supervision and Site Acceptance Testing (SAT)

1. Where field assembly of custom air handling units is required, the manufacturer shall provide on-site assembly supervision by a qualified factory technician.
2. Manufacturer representative shall be present when unit(s) arrive and are unloaded at the project site. Provide erection supervision.
3. Provide start-up services to supervise the initial start-up of the air handler motor controllers including variable frequency drives. Minimum 2 days onsite. Provide written start-up procedures thirty (30) days prior to start-up of unit.
4. Repeat Factory Acceptance Testing as specified herein at the project site (SAT-Site Acceptance Testing). Provide accompanying SAT report similar to FAT report verifying results and comparing to results in factory. All deficiencies must be corrected prior to completion of project close-out. SAT report shall be used in conjunction with all required commissioning documents by the project Commissioning Authority.
5. Unit shall be furnished with shipping splits. Provide on-site assembly supervision by a qualified factory technician.
6. The assembled unit shall be field tested for air leakage within the AHU air tunnel using a calibrated orifice plate or flow tube. The AHU ductwork shall be tested again for leakage to confirm all flanges/permanently welded joints at shipping splits have been tightly sealed. Piping systems shall be retested for leakage.

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7. Provide field vibration testing equivalent to factory testing procedures once AHU has been set on prefabricated AHU support dunnage as part of start-up services.
8. Provide field acoustical performance testing equivalent to factory testing procedures once AHU has been fully assembled and site acceptance testing begins. Perform this testing early to ensure there are no noise concerns at OA intake, relief, exterior panels. Coordinate all other equipment/component testing and verification requirements in compliance with project commissioning/testing and verification specifications. Coordinate with project commissioning agent/VAMC COR.
9. Confirm installing contractor coordinates all equipment support and flashing requirements and notes in start-up report.
10. All start-up action shall be documented. Start AHU according to manufacturer's instructions. Operate, adjust and verify all controls and safeties.

3.2 CLEANING PRIOR TO SHIPMENT

- A. Interior and exterior surfaces shall be cleaned to remove dust, dirt, oil, grease, rust inhibitors, metal flakes, chips, residues from manufacturing and assembly processes and other foreign materials.
- B. Water, oil, or other liquids used for cleaning or testing are to be drained from equipment before shipping. Oils required for proper operation shall be replaced and maintained at proper levels.

3.3 PREPARATION AND SHIPMENT

- A. Machined surfaces including faces of mild steel flanges shall be protected and coated with suitable rust preventive coating.
- B. Openings shall be sealed to prevent entrance of foreign materials. Flange faces shall be protected with wooden or plastic flange covers, taped to provide waterproof protection. Threaded connections shall be protected with plastic thread protection caps.
- C. Accessories and parts which are shipped loose shall be boxed and properly identified with durable shipping tags that are securely attached to each package and marked with its related equipment name, assembly location, Purchase Order number, assembly series number (if applicable), shop order number and purchaser's name. Separate

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packages for a single item shall also be marked so as to identify component(s) in each package, and number of packages in each shipment.

- D. Parts shall be adequately braced, protected, and packaged to prevent damage during shipment. Unit section(s) shall be shrink-wrapped to protect the unit during shipment.
- E. The Purchase Order Number, Equipment Item Number and Vendor order/tracking number shall be prominently displayed on equipment skids and shipping containers or crates.
- F. Adequate instruction, labeled "Special Lifting and Handling" shall be attached if special handling and unpacking are required.

3.4 DELIVERY

- A. Manufacturer shall furnish and ship equipment.
- B. Manufacturer shall pack, crate and protect equipment to prevent damage from handling, weather, shock, vibration, water and corrosion during shipment. Wrap packaged or crated assemblies in weatherproof plastic sheeting prior to shipment.
- C. Manufacturer shall include complete handling and installation data with equipment when shipped to the job site.
- D. Damaged equipment will not be accepted at the job site.

3.5 COMMISSIONING (INSTALLING CONTRACTOR)

- 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
- C. Verify that building automation/BAS controls and electrical wiring installation complies with manufacturer's submittal and installation requirements of Division 23, 26 and 28 Sections. Do not proceed with AHU startup until wiring installation is acceptable to equipment installer.
- D. Start AHU according to manufacturer's instructions.

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- E. Operate and adjust controls and safeties.
- F. All start-up action shall be documented.

3.6 DEMONSTRATION (MANUFACTURER)

- A. Factory-authorized service representative shall demonstrate AHU and train Owner's maintenance personnel. Minimum 1 day on site. Submit course agenda three (3) days prior to training session. Provide resume of training instructor and record the training session and turn over DVD, CD or tape to owner.
- B. Operate AHU including accessories and controls, to demonstrate compliance with requirements.
- C. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.
- D. Engage a factory-authorized service representative of the supply fan manufacturer to train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans. Refer to Division 1 Section "Demonstration and Training."
- E. Schedule training with Owner with at least forty (40) days advance notice.
- F. All training shall be documented.

3.7 EXAMINATION (INSTALLING CONTRACTOR)

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine casing insulation materials and filter media before air-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for steam, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.8 INSTALLATION (INSTALLING CONTRACTOR)

- A. Equipment Mounting: Install air-handling unit without vibration isolation devices. Comply with requirements for vibration isolation

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devices specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

- B. Arrange installation of units to provide access space around air-handling units for service and maintenance. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.
- C. Install filter-gage, static-pressure taps upstream and downstream of filters. Mount filter gages on outside of filter housing or filter plenum in accessible position. Provide filter gages on filter banks, installed with separate static-pressure taps upstream and downstream of filters.

3.9 CONNECTIONS (MANUFACTURER)

- A. Comply with requirements for piping specified in other Division 23 Sections. Drawings and applicable details indicate general arrangement of piping, fittings, and specialties.
- B. Install piping within service corridor to allow service and maintenance. Connect to each coil, humidifier, etc. without blocking access into AHU air tunnel via access doors/access door swings, etc. AHU manufacturer shall extend all component piping through AHU air tunnel casing and within service corridor to point shown on AHU configuration diagram and plan drawings for connection/continuation by installing (mechanical) contractor. Intent is for piping to be routed high with service corridor areas to allow unobstructed access/head height clearance. Mount control valves and isolation valves in accessible locations within Service corridor.
- C. Connect piping to air-handling unit mounted on vibration isolators with flexible connectors.
- D. Connect to condensate drain pans using NPS 1-1/4, ASTM B 88, Type M copper tubing. Extend to floor drains without creating a tripping hazard and to promote proper drainage to adjacent floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction. AHU air tunnel drain pans shall 304 stainless steel and shall be raised as indicated herein to ensure proper trapping as specified and indicated by trap details. Floor drain pipes

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shall be extended down through PEM base rail by manufacturer. Coordinate all drainage piping locations for field piping extending up from below AHU floor.

- E. Chilled-Water and Heating Hot Water Piping: Comply with applicable requirements in Division 23 piping specifications and piping/valve specifications. Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection. Refer to piping and component details and pipe/insulation material schedule for additional requirements.
- F. Steam and Condensate Piping: Comply with applicable requirements in Division 23 steam and condensate specifications and piping/valve data sheets. Install gate valve and inlet strainer at supply connection of dry steam humidifiers, and inverted bucket steam trap to condensate return connection. Refer to piping and component details and pipe/insulation material schedule for additional requirements.
- G. Ductwork: Comply with applicable requirements in Division 23 ducts and casings specifications. Connect ductwork to air-handling units mounted on vibration isolators with fire rated flexible connections. Refer to contract drawings for additional requirements.

3.10 ADJUSTING (INSTALLING CONTRACTOR)

- A. Adjust damper linkages for proper damper operation.
- B. Comply with requirements in Division 23 Section "Testing, Adjusting, and Balancing" for air-handling system testing, adjusting, and balancing.
- C. Comply with requirements in Specification Sections 01 91 00, GENERAL COMMISSIONING REQUIREMENTS and 23 08 00, COMMISSIONING OF HVAC SYSTEMS. Installing contractor shall coordinate efforts of all disciplines for rigging/mounting, utility connections, BAS/controls integration to site BAS, TAB, Site Testing/Verification/Commissioning efforts, etc.

3.11 CLEANING (INSTALLING CONTRACTOR)

- A. After completing system installation and testing, adjusting, and balancing air-handling unit, Heating hot water system and air-distribution systems and after completing startup services, clean air-handling unit air tunnel/internal components and all access/service

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corridor areas internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

- B. Interior and exterior surfaces shall be cleaned to remove dust, dirt, oil, grease, rust inhibitors, metal flakes, chips, residues from rigging and assembly processes and other foreign materials. Water, oil, or other liquids used for cleaning or testing are to be drained from equipment before shipping. Oils required for proper operation shall be replaced and maintained at proper levels

3.12 STARTUP SERVICES

- A. The custom air handling unit, including but not limited to the return/relief fans, coils, etc. shall not be operated for any purpose, temporary or permanent, until AHU is clean, ductwork is clean, piping is clean, piping system has been flushed and filled, water treatment complete, AHU air filters are in place and active, fan bearings are lubricated and fans have been test run (including site noise & vibration testing) under observation.
- B. After the complete custom air handling units, including but not limited to the return/relief fans, coils, etc. is installed and tested/verified/commissioned, provide startup and operating instructions to VA personnel.
- C. An authorized factory representative should start up, test and certify the final installation and application specific calibration of control components. Items to be verified as part of site acceptance testing include: fan performance over entire operating range, noise and vibration testing, verification of proper fan alignment, AHU air tunnel site leakage testing, final ductwork and piping leakage testing, overall inspection of the installation, Owner/Operator training, etc.
- D. Provide training and instruction for VA engineering, operations and maintenance personnel in accordance with Article, INSTRUCTIONS, of Section 01 00 00, GENERAL REQUIREMENTS, and Section 23 08 00, COMMISSIONING OF HVAC.

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SECTION 23 81 00
DECENTRALIZED UNITARY HVAC EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies split-systems.

B. Definitions:

1. Energy Efficiency Ratio (EER): The ratio of net cooling capacity is Btu/h to total rate of electricity input in watts under designated operating conditions (Btu hour/Watt).
2. Seasonal Energy Efficiency Ratio (SEER): The ratio of the total cooling output of an air conditioner during its normal annual usage period for cooling in Btu/h divided by total electric energy input in watts during the same period (Btu hour/Watt).
3. Integrated Energy Efficiency Ratio (IEER). A single number cooling part-load efficiency figure of merit expressed in Btu/(Wh) and calculated as follows:

$$\text{IEER} = (0.020 \times A) + (0.617 \times B) + (0.238 \times C) + (0.125 \times D)$$

Where:

A = EER at 100% net capacity at AHRI Standard Conditions

B = EER at 75% net capacity and reduced air entering outdoor unit conditions - 82°F DB/65°F WB.

C = EER at 50% net capacity and reduced air entering outdoor unit conditions - 82°F DB/ - .

D = EER at 25% net capacity and reduced air entering outdoor unit conditions - 82°F DB/ - .

4. Unitary: A Unitary Air Conditioner consists of one or more factory-made assemblies which normally include an evaporator or cooling coil, a compressor and condenser combination, and may include a heating function as well.
5. Where such equipment is provided in more than one assembly the separated assemblies are to be designed to be used together and the requirements of rating are based upon use of matched assemblies.

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1.2 RELATED WORK

- A. Section 01 00 00, GENERAL REQUIREMENTS: Requirements for pre-test of equipment: Seismic requirements for non-structural equipment.
- B. Section 23 05 11, COMMON WORK RESULTS FOR HVAC: General mechanical requirements and items, which are common to more than one section of Division 23.
- C. Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT: Requirements for different types of vibration isolators and noise ratings in the occupied areas.
- D. Section 23 07 11, HVAC and BOILER PLANT INSULATION: Requirements for piping insulation.
- E. Section 23 23 00, REFRIGERANT PIPING: Requirements for refrigerant pipes and fittings.
- F. Section 23 36 00, AIR TERMINAL UNITS and Section 23 82 00, CONVECTION HEATING and COOLING UNITS: Requirements for other similar units.
- G. Section 23 73 43, CUSTOM, INDOOR, CENTRAL-STATION AIR-HANDLING UNITS: Requirements for air handling units using chilled water and hot water coils
- H. Section 23 74 43, CUSTOM, OUTDOOR, CENTRAL-STATION AIR-HANDLING UNITS: Requirements for air handling units using chilled water and hot water coils.
- I. Section 23 40 00, HVAC AIR CLEANING DEVICES: Requirements for air filtration.
- J. Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS: Requirements for commissioning, systems readiness checklists, and training.
- K. Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC: Requirements for testing and adjusting air balance.

1.3 QUALITY ASSURANCE

- A. Refer to specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Safety Standards: ASHRAE Standard 15, Safety Code for Mechanical Refrigeration.

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:

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1. Sufficient information, including capacities, pressure drops and piping connections clearly presented, shall be included to determine compliance with drawings and specifications for units noted below:
 - a. Unitary air conditioners:
 - 1) Split systems
 2. Unit Dimensions required clearances, operating weights accessories and start-up instructions.
 3. Electrical requirements, wiring diagrams, interlocking and control wiring showing factory installed and portions to be field installed.
 4. Mounting and flashing of the roof supports to the roofing structure with coordinating requirements for the roof membrane system.
- C. Certification: Submit proof of specified ARI Certification.
- D. Performance Rating: Submit catalog selection data showing equipment ratings and compliance with required sensible-to-heat-ratio, energy efficiency ratio (EER), Integrated Energy Efficiency Ratio (IEER), and coefficient of performance (COP). All data shall indicate compliance with performance ratings as listed in ASHRAE 90.1-2013, Energy Standard for Buildings Except Low-Rise Residential Buildings.
- E. Operating and Maintenance Manual: Submit three copies of Operating and Maintenance manual to the Contracting Officers Representative (COR) three weeks prior to final inspection.
- F. Completed System Readiness Checklists provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 23 08 00 COMMISSIONING OF HVAC SYSTEMS.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. Federal Specifications (Fed. Spec.):

A-A-50502-90..... Air conditioner (Unitary Heat Pump) Air to Air
(3000-300,000 Btu)
- C. Military Specifications (Mil. Specs.):

MIL-PRF-26915D-06.....Primer Coating, for Steel Surfaces
- D. Air-Conditioning, Heating, and Refrigeration Institute (AHRI):

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- 210/240-08.....Performance Rating of Unitary Air-Conditioning
and Air-Source Heat Pump Equipment
- 270-08.....Sound Rating of Outdoor Unitary Equipment
- 340/360-07.....Performance Rating of Commercial and Industrial
Unitary Air-Conditioning and Heat Pump
Equipment
- 520-04.....Performance Rating of Positive Displacement
Condensing Units
- E..Air Conditioning, Heating and Refrigeration Institute (AHRI):
- 1230-10.....Performance Rating of Variable Refrigerant Flow
(VRF) Multi-Split Air Conditioning and Heat
Pump Equipment
- F..Air Movement and Control Association (AMCA):
- 210-07.....Laboratory Methods of Testing Fans for
Aerodynamic Performance Rating (ANSI)
- 410-96.....Recommended Safety Practices for Users and
Installers of Industrial and Commercial Fans
- G. American National Standards Institute (ANSI):
- S12.51-02(R2007).....Acoustics - Determination of Sound Power Levels
of Noise Sources Using Sound Pressure -
Precision Method for Reverberation Rooms (same
as ISO 3741:1999)
- H. American Society of Heating, Refrigerating, and Air-Conditioning
Engineers (ASHRAE):
- 2012 Handbook.....HVAC Systems and Equipment
- 15-13.....Safety Standard for Refrigeration Systems
(ANSI)
- 34-13.....Designation and Classification of Refrigerants
(ANSI)
- I. American Society of Testing and Materials (ASTM):
- B117-09.....Standard Practice for Operating Salt Spray
(Fog) Apparatus
- J. American Society of Civil Engineers (ASCE)
- ASCE 7-10.....Minimum Design Loads for Buildings and Other
Structures

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K. National Electrical Manufacturer's Association (NEMA):

MG 1-09 (R2010).....Motors and Generators (ANSI)

ICS 1-00 (R2005, R2008).Industrial Controls and Systems: General
Requirements

L. National Fire Protection Association (NFPA) Publications:

90A-15.....Standard for the Installation of Air-
Conditioning and Ventilating Systems

PART 2 - PRODUCTS

2.1 UNITARY AIR CONDITIONERS - GENERAL

A. Applicable ARI Standards:

1. Cooling Capacity 39.6 kW (135,000 Btu/h) and More: AHRI 340/ 360.

2. Cooling Capacity Less Than 39.6 kW (135,000 Btu/h): AHRI 210/240.

Units shall be listed in the ARI Directory of Certified Unitary Air-
Conditioners.

B. Performance Rating: Cooling capacity of units shall meet the sensible
heat and total heat requirements shown in the contract documents. In
selecting unit size, make true allowance for "sensible to total heat
ratio" to satisfy required sensible cooling capacity.

C. Machinery Guards: Provide guards as shown in AMCA 410 for belts,
chains, couplings, pulleys, sheaves, shafts, gears and other moving
parts regardless of height above the floor. Drive guards may be
excluded where motors and drives are inside factory fabricated casings.

D. Corrosion Prevention: Unless specified otherwise, equipment fabricated
from ferrous metals that do not have a zinc coating or a duplex coating
of zinc and paint shall be treated for prevention of rust with a
factory coating or paint system that will withstand 125 hours in a
salt-spray fog test, except that equipment located outdoors shall be
tested for 500 hours. The salt-spray fog test shall be in accordance
with ASTM B117 using a 20 percent sodium chloride solution. Immediately
after completion of the test, the coating shall show no signs of
blistering, wrinkling or cracking, no loss of adhesion, and the
specimen shall show no signs of rust beyond 3 mm (1/8-inch) on both
sides from the scratch mark.

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2.2 SPLIT-SYSTEM AIR CONDITIONERS

- A. Description: Factory assembled and tested, floor-mounted, wall-mounted, or ceiling mounted unit, with an air-cooled remote condensing unit, and field-installed refrigeration piping.
- B. Concealed Evaporator Components:
 - 1. Chassis: Galvanized steel with flanged edges, removable panels for servicing, and insulation on back of panel.
 - 2. Insulation: Factory-applied duct liner.
 - 3. Drain Pans: Galvanized steel, with connection for drain; insulated and complying with ASHRAE 62.1-2013.
 - 4. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2013.
 - 5. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with AHRI 210/240, and with thermal-expansion valve.
 - 6. Fan: Forward-curved, double-width wheel of galvanized steel; directly connected to motor.
 - 7. Fan Motors: Comply with requirements in Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION EQUIPMENT for multi-tapped, multi-speed motors with internal thermal protection and permanent lubrication.
 - 8. Disposable Filters: 25 mm (1 inch) thick, in fiberboard frames.
 - 9. Wiring Terminations: Connect motor to chassis wiring with plug connection.
- C. Floor-Mounting, Evaporator-Fan Components:
 - 1. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect.
 - 2. Discharge Grille: Steel with surface-mounted frame.
 - 3. Insulation: Factory-installed duct liner.
 - 4. Drain Pans: Galvanized steel, with connection for drain; insulated and complying with ASHRAE 62.1-2013.
 - 5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2013.
 - 6. Coils:

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- a. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with AHRI 210/240, and with thermal-expansion valve.
 7. Fan: Direct drive, centrifugal.
 8. Fan Motors: Comply with requirements in Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION EQUIPMENT for multi-tapped, multi-speed motors with internal thermal protection and permanent lubrication.
 9. Filters: Disposable, with MERV rating of 7 or higher according to ASHRAE 52.2.
- D. Wall-Mounting, Evaporator-Fan Components:
1. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection.
 2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2013.
 3. Drain Pan and Drain Connection: Comply with ASHRAE 62.1-2013.
 4. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with AHRI 210/240, and with thermal-expansion valve.
 5. Fan: Direct drive, centrifugal fan.
 6. Fan Motors: Comply with requirements in Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION EQUIPMENT for multi-tapped, multi-speed motors with internal thermal protection and permanent lubrication.
 7. Filters: Disposable, with MERV rating of 7 or higher according to ASHRAE 52.2.
- E. Ceiling-Mounting, Evaporator-Fan Components:
1. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection.
 2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2013.
 3. Drain Pan and Drain Connection: Comply with ASHRAE 62.1-2013.
 4. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with AHRI 210/240, and with thermal-expansion valve.

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5. Fan: Direct drive, centrifugal fan, and integral condensate pump.
6. Fan Motors: Comply with requirements in Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION EQUIPMENT for multi-tapped, multi-speed motors with internal thermal protection and permanent lubrication.
7. Filters: Disposable, with MERV rating of 7 or higher according to ASHRAE 52.2.

F. Air-Cooled, Compressor-Condenser Components:

1. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Service valves, fittings, and gage ports shall be brass and located outside of the casing.
2. Compressor: Hermetically sealed scroll with crankcase heater and mounted on vibration isolation. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
3. Compressor motor with manual-reset, high-pressure switch and automatic-reset, low-pressure switch.
4. Refrigerant: R-410A unless otherwise indicated.
5. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with AHRI 210/240, and with liquid subcooler.
6. Fan: Aluminum, propeller type, directly connected to motor.
7. Motor: Permanently lubricated, with integral thermal-overload protection.
8. Low Ambient Kit: Permit operation down to minus 18 deg C (0 deg F).
9. Mounting Base: Polyethylene.

Minimum Energy Efficiency: Comply with ASHRAE/IESNA 90.1-2013, "Energy Standard for Buildings except Low-Rise Residential Buildings."

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install roof-mounting compressor-condenser components on equipment supports. Anchor units to supports with removable, cadmium-plated fasteners.

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- B. Install compressor-condenser components on restrained, spring isolators with a minimum static deflection of 25 mm (1 inch) unless otherwise indicated. Refer to Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.
- C. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.
- D. Install wall sleeves in finished wall assembly and weatherproof. Install and anchor wall sleeves to withstand, without damage seismic forces as required by code.

3.2 CONNECTIONS

- A. Verify condensate drainage requirements.
- B. Install condensate drain, minimum connection size, with trap and indirect connection to nearest roof drain or area drain.
- C. Install piping adjacent to units to allow service and maintenance.
- D. Ground equipment and install power wiring, switches, and controls for self contained and split systems.
- E. Connect refrigerant piping to coils with shutoff valves on the suction and liquid lines at the coil and a union or flange at each connection at the coil and condenser.

3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
- B. Tests and Inspections: After installing units and after electrical circuitry has been energized, test units for compliance with requirements. Inspect for and remove shipping bolts, blocks, and tie-down straps. After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment. Remove and replace malfunctioning units and retest as specified above.

3.4 INSTRUCTIONS

- A. Provide services of manufacturer's technical representative for four hours to instruct VA personnel in operation and maintenance of units.

3.5 STARTUP AND TESTING

- A. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing

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schedules with the COR and Commissioning Agent. Provide a minimum of 7 days prior notice.

3.6 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.
- B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

3.7 DEMONSTRATION AND TRAINING

- A. Provide services of manufacturer's technical representative for 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 82 00
CONVECTION HEATING AND COOLING UNITS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Unit heaters

1.2 RELATED WORK

- A. Section 23 05 11, COMMON WORK RESULTS FOR HVAC: General mechanical requirements and items, which are common to more than one section of Division 23.
- B. Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT: Noise requirements.
- C. Section 23 21 13, HYDRONIC PIPING: Heating hot water and chilled water piping.
- D. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC: Valve operators.
- E. Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC: Flow rates adjusting and balancing.
- F. Section 23 82 16, AIR COILS: Additional coil requirements.
- G. Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS: Requirements for commissioning, systems readiness checklists, and training.
- H. Section 01 09 00 - GENERAL COMMISSIONING REQUIREMENTS

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Manufacturer's Literature and Data:
 - 1. Unit heaters.
- C. Certificates:
 - 1. Compliance with paragraph, QUALITY ASSURANCE.
 - 2. Compliance with specified standards.
- D. Operation and Maintenance Manuals: Submit in accordance with paragraph, INSTRUCTIONS, in Section 01 00 00, GENERAL REQUIREMENTS.
- E. Completed System Readiness Checklists provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician

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and dated on the date of completion, in accordance with the
requirements of Section 23 08 00 COMMISSIONING OF HVAC SYSTEMS.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. American National Standards Institute / Air Conditioning, Heating and Refrigeration Institute (ANSI/AHRI):
 - 440-08.....Performance Rating of Room Fan Coils
 - National Fire Protection Association (NFPA):
 - 90A-15.....Standard for the Installation of Air
Conditioning and Ventilating Systems
 - 70-14.....National Electrical Code
- C. Underwriters Laboratories, Inc. (UL):
 - 181-08.....Standard for Factory-Made Air Ducts and Air
Connectors
 - 1995-05.....Heating and Cooling Equipment

1.6 GUARANTY

- A. In accordance with FAR clause 52.246-21.

PART 2 - PRODUCTS

2.1 UNIT HEATERS

- A. General: Horizontal or vertical discharge type for steam, hot water or electric heating medium, 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.
- E. Steam or Hot Water Coil: Aluminum fins bonded to seamless copper tubing by mechanical expansion of the tubing, designed for 517 kPa (75 psig) steam working pressure.
- F. Controls: Provide field installed remote wall mounted line voltage electric space thermostats where shown or specified to control the unit

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fan. Provide an aquastat on steam or hot water units to prevent fan operation when the heating system is off.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Work shall be installed as shown and according to the manufacturer's diagrams and recommendations.
- B. Handle and install units in accordance with manufacturer's written instructions.
- C. Support units rigidly so they remain stationary at all times. 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.
- D. Install fiberglass blanket insulation with a minimum R value of 8 above hydronic radiant panels.

3.2 OPERATIONAL TEST

- A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

3.3 STARTUP AND TESTING

- A. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the Contracting Officers Representative (COR) and Commissioning Agent. Provide a minimum of 7 days prior notice.

3.4 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.
- B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

3.5 DEMONSTRATION AND TRAINING

- A. Provide services of manufacturer's technical representative for four hours to instruct VA personnel in operation and maintenance of units.
- B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS.

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SECTION 23 82 16
AIR COILS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Heating and cooling coils for air handling unit and duct applications

1.2 RELATED WORK

- A. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.
- B. Section 23 31 00, HVAC DUCTS AND CASINGS
- C. Section 23 36 00, AIR TERMINAL UNITS: Reheat coils for VAV/CV terminals.
- D. Section 23 73 43, CUSTOM, INDOOR CENTRAL-STATION AIR-HANDLING UNITS.
- E. Section 23 74 43, CUSTOM, OUTDOOR CENTRAL-STATION AIR-HANDLING UNITS.
- F. Section 23 82 00, HEATING AND COOLING UNITS
- G. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS: Requirements for commissioning, systems readiness checklists, and training.
- H. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS

1.3 QUALITY ASSURANCE

- A. Refer to paragraph, QUALITY ASSURANCE, 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 Standard 410 and shall bear the AHRI certification label.

1.4 SUBMITTALS

- A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Manufacturer's Literature and Data for Heating and Cooling Coils: Submit type, size, arrangements and performance details. Present application ratings in the form of tables, charts or curves.
- C. Provide installation, operating and maintenance instructions.
- D. Certification Compliance: Evidence of listing in current ARI Directory of Certified Applied Air Conditioning Products.
- E. Coils may be submitted with Section 23 74 43, CUSTOM, OUTDOOR, CENTRAL-STATION AIR-HANDLING UNITS, Section 23 36 00, AIR TERMINAL UNITS, or Section 23 82 00, HEATING AND COOLING UNITS.

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- F. Completed System Readiness Checklists provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 23 08 00 COMMISSIONING OF HVAC SYSTEMS.

1.5 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. Air Conditioning and Refrigeration Institute (AHRI):
Directory of Certified Applied Air Conditioning Products
AHRI 410-01.....Forced-Circulation Air-Cooling and Air-Heating Coils
- C. American Society for Testing and Materials (ASTM):
B75/75M-02.....Standard Specifications for Seamless Copper Tube
- D. National Fire Protection Association (NFPA):
70-14.....National Electric Code
- E. National Electric Manufacturers Association (NEMA):
250-14.....Enclosures for Electrical Equipment (1,000 Volts Maximum)
- F. Underwriters Laboratories, Inc. (UL):
1996-09.....Electric Duct Heaters

PART 2 - PRODUCTS

2.1 HEATING AND COOLING COILS

- A. Conform to ASTM B75 and AHRI 410.
- B. Tubes: Minimum 16 mm (0.625 inch) tube diameter; Seamless copper tubing.
- C. Fins: 0.1397 mm (0.0055 inch) aluminum or 0.1143 mm (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.

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- F. Coil Casing: 1.6 mm (16 gage) galvanized steel with tube supports at 1200 mm (48 inch) maximum spacing. Construct casing to eliminate air bypass and moisture carry-over. Provide duct connection flanges.
- G. Pressures PSIG: Coils shall be designed to withstand 250 psig maximum operating pressures and a maximum fluid temperature of 300°F for standard duty copper tube coils.
- 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.
- J. Cooling Coil Condensate Drain Pan: Section 23 74 43, CUSTOM, OUTDOOR, CENTRAL-STATION AIR-HANDLING UNITS.
- K. Steam Distributing Coils: Conform to ASTM B75 and ARI 410. Minimum 9.5 mm (3/8-inch) steam distributing tubing installed concentrically in 25 mm (one-inch) OD condensing coil tubes.
- L. Dampers: Interlocking opposed blades to completely isolate coil from air flow when unit is in bypass position; 1.6 mm (16 gage) steel, coated with factory applied corrosion resistant baked enamel finish. Provide damper linkage and electric operators. Damper operators shall be of same manufacturer as controls furnished under Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

2.2 REHEAT COILS, DUCT MOUNTED

- A. The coils shall be continuous circuit booster type for steam or hot water as shown on drawings. Use the same coil material as listed in Paragraphs 2.1.

2.3 WATER COILS, INCLUDING GLYCOL-WATER

- A. Use the same coil material as listed in Paragraphs 2.1.
- B. Drainable Type (Self Draining, Self Venting); Manufacturer standard:
 - 1. Cooling, all types.
 - 2. Heating or preheat.
 - 3. Runaround energy recovery. ARI certification of capacity adjustment is waived. See Section 23 72 00, AIR-TO-AIR ENERGY RECOVERY EQUIPMENT.

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PART 3 - EXECUTION

3.1 INSTALLATION

- A. Follow coil manufacturer's instructions for handling, cleaning, installation and piping connections.
- B. Comb fins, if damaged. Eliminate air bypass or leakage at coil sections.

3.2 STARTUP AND TESTING

- A. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the Contracting Officers Representative (COR) and Commissioning Agent. Provide a minimum of 7 days prior notice.

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 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 26 05 11
REQUIREMENTS FOR ELECTRICAL INSTALLATIONS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section applies to all sections of Division 26.
- B. Furnish and install electrical systems, materials, equipment, and accessories in accordance with the specifications and drawings. Capacities and ratings of motors, conductors and cable, motor control centers, and other items and arrangements for the specified items are shown on the drawings.
- C. Conductor ampacities specified or shown on the drawings are based on copper conductors, with the conduit and raceways sized per NEC. Aluminum conductors are prohibited.

1.2 MINIMUM REQUIREMENTS

- A. The International Building Code (IBC), National Electrical Code (NEC), Underwriters Laboratories, Inc. (UL), and National Fire Protection Association (NFPA) codes and standards are the minimum requirements for materials and installation.
- B. The drawings and specifications shall govern in those instances where requirements are greater than those stated in the above codes and standards.

1.3 TEST STANDARDS

- A. All materials and equipment shall be listed, labeled, or certified by a Nationally Recognized Testing Laboratory (NRTL) to meet Underwriters Laboratories, Inc. (UL), standards where test standards have been established. Materials and equipment which are not covered by UL standards will be accepted, providing that materials and equipment are listed, labeled, certified or otherwise determined to meet the safety requirements of a NRTL. Materials and equipment which no NRTL accepts, certifies, lists, labels, or determines to be safe, will be considered if inspected or tested in accordance with national industrial standards, such as ANSI, NEMA, and NETA. Evidence of compliance shall include certified test reports and definitive shop drawings.
- B. Definitions:

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1. Listed: Materials and equipment included in a list published by an organization that is acceptable to the Authority Having Jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production or listed materials and equipment or periodic evaluation of services, and whose listing states that the materials and equipment either meets appropriate designated standards or has been tested and found suitable for a specified purpose.
2. Labeled: Materials and equipment to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the Authority Having Jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled materials and equipment, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.
3. Certified: Materials and equipment which:
 - a. Have been tested and found by a NRTL to meet nationally recognized standards or to be safe for use in a specified manner.
 - b. Are periodically inspected by a NRTL.
 - c. Bear a label, tag, or other record of certification.
4. Nationally Recognized Testing Laboratory: Testing laboratory which is recognized and approved by the Secretary of Labor in accordance with OSHA regulations.

1.4 QUALIFICATIONS (PRODUCTS AND SERVICES)

- A. Manufacturer's Qualifications: The manufacturer shall regularly and currently produce, as one of the manufacturer's principal products, the materials and equipment specified for this project, and shall have manufactured the materials and equipment for at least three years.
- B. Product Qualification:
 1. Manufacturer's materials and equipment shall have been in satisfactory operation, on three installations of similar size and type as this project, for at least three years.

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2. The Government reserves the right to require the Contractor to submit a list of installations where the materials and equipment have been in operation before approval.

C. Service Qualifications: There shall be a permanent service organization maintained or trained by the manufacturer which will render satisfactory service to this installation within eight hours of receipt of notification that service is needed. Submit name and address of service organizations.

1.5 APPLICABLE PUBLICATIONS

- A. Applicable publications listed in all Sections of Division 26 are the latest issue, unless otherwise noted.
- B. Products specified in all sections of Division 26 shall comply with the applicable publications listed in each section.

1.6 MANUFACTURED PRODUCTS

- A. Materials and equipment furnished shall be of current production by manufacturers regularly engaged in the manufacture of such items, and for which replacement parts shall be available. Materials and equipment furnished shall be new, and shall have superior quality and freshness.
- B. When more than one unit of the same class or type of materials and equipment is required, such units shall be the product of a single manufacturer.
- C. Equipment Assemblies and Components:
 - 1. Components of an assembled unit need not be products of the same manufacturer.
 - 2. Manufacturers of equipment assemblies, which include components made by others, shall assume complete responsibility for the final assembled unit.
 - 3. Components shall be compatible with each other and with the total assembly for the intended service.
 - 4. Constituent parts which are similar shall be the product of a single manufacturer.
- D. Factory wiring and terminals shall be identified on the equipment being furnished and on all wiring diagrams.

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E. When Factory Tests are specified, Factory Tests shall be performed in the factory by equipment manufacturer, and witnessed by the contractor.

In addition, the following requirements shall be complied with:

1. The Government shall have the option of witnessing factory tests.
The Contractor shall notify the Government through the COR a minimum of thirty (30) days prior to the manufacturer's performing of the factory tests.
2. When factory tests are successful, contractor shall furnish four (4) copies of the equipment manufacturer's certified test reports to the COR fourteen (14) days prior to shipment of the equipment, and not more than ninety (90) days after completion of the factory tests.
3. When factory tests are not successful, factory tests shall be repeated in the factory by the equipment manufacturer, and witnessed by the Contractor. The Contractor shall be liable for all additional expenses for the Government to witness factory re-testing.

1.7 VARIATIONS FROM CONTRACT REQUIREMENTS

- A. Where the Government or the Contractor requests variations from the contract requirements, the connecting work and related components shall include, but not be limited to additions or changes to branch circuits, circuit protective devices, conduits, wire, feeders, controls, panels and installation methods.

1.8 MATERIALS AND EQUIPMENT PROTECTION

- A. Materials and equipment shall be protected during shipment and storage against physical damage, vermin, dirt, corrosive substances, fumes, moisture, cold and rain.
1. Store materials and equipment indoors in clean dry space with uniform temperature to prevent condensation.
 2. During installation, equipment shall be protected against entry of foreign matter, and be vacuum-cleaned both inside and outside before testing and operating. Compressed air shall not be used to clean equipment. Remove loose packing and flammable materials from inside equipment.
 3. Damaged equipment shall be repaired or replaced, as determined by the COR.

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4. Painted surfaces shall be protected with factory installed removable heavy kraft paper, sheet vinyl or equal.
5. Damaged paint on equipment shall be refinished with the same quality of paint and workmanship as used by the manufacturer so repaired areas are not obvious.

1.9 WORK PERFORMANCE

- A. All electrical work shall comply with the requirements of NFPA 70 (NEC), NFPA 70B, NFPA 70E, OSHA Part 1910 subpart J - General Environmental Controls, OSHA Part 1910 subpart K - Medical and First Aid, and OSHA Part 1910 subpart S - Electrical, in addition to other references required by contract.
- B. Job site safety and worker safety is the responsibility of the Contractor.
- C. Electrical work shall be accomplished with all affected circuits or equipment de-energized. When an electrical outage cannot be accomplished in this manner for the required work, the following requirements are mandatory:
 1. Electricians must use full protective equipment (i.e., certified and tested insulating material to cover exposed energized electrical components, certified and tested insulated tools, etc.) while working on energized systems in accordance with NFPA 70E.
 2. Before initiating any work, a job specific work plan must be developed by the Contractor with a peer review conducted and documented by the COR and Medical Center staff. The work plan must include procedures to be used on and near the live electrical equipment, barriers to be installed, safety equipment to be used, and exit pathways.
 3. Work on energized circuits or equipment cannot begin until prior written approval is obtained from the COR.
- D. For work that affects existing electrical systems, arrange, phase and perform work to assure minimal interference with normal functioning of the facility. Refer to Section 01 00 00, GENERAL REQUIREMENTS.
- E. New work shall be installed and connected to existing work neatly, safely and professionally. Disturbed or damaged work shall be replaced

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or repaired to its prior conditions, as required by Section 01 00 00,
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- F. Coordinate location of equipment and conduit with other trades to minimize interference.

1.10 EQUIPMENT INSTALLATION AND REQUIREMENTS

- A. Equipment location shall be as close as practical to locations shown on the drawings.
- B. Working clearances shall not be less than specified in the NEC.
- C. Inaccessible Equipment:
1. Where the Government determines that the Contractor has installed equipment not readily accessible for operation and maintenance, the equipment shall be removed and reinstalled as directed at no additional cost to the Government.
 2. "Readily accessible" is defined as being capable of being reached quickly for operation, maintenance, or inspections without the use of ladders, or without climbing or crawling under or over obstacles such as, but not limited to, motors, pumps, belt guards, transformers, piping, ductwork, conduit and raceways.
- D. Electrical service entrance equipment and arrangements for temporary and permanent connections to the electric utility company's system shall conform to the electric utility company's requirements. Coordinate fuses, circuit breakers and relays with the electric utility company's system, and obtain electric utility company approval for sizes and settings of these devices.

1.11 EQUIPMENT IDENTIFICATION

- A. In addition to the requirements of the NEC, install an identification sign which clearly indicates information required for use and maintenance of items such as panelboards, cabinets, motor controllers, fused and non-fused safety switches, separately enclosed circuit breakers, individual breakers, and motor control assemblies, control devices and other significant equipment.
- B. Identification signs for Normal Power System equipment shall be laminated black phenolic resin with a white core with engraved lettering. Identification signs for Essential Electrical System (EES) equipment, as defined in the NEC, shall be laminated red phenolic resin

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with a white core with engraved lettering. Lettering shall be a minimum of 12 mm (1/2 inch) high. Identification signs shall indicate equipment designation, rated bus amperage, voltage, number of phases, number of wires, and type of EES power branch as applicable. Secure nameplates with screws.

- C. Install adhesive arc flash warning labels on all equipment as required by NFPA 70E. Label shall show specific and correct information for specific equipment based on its arc flash calculations. Label shall show the followings:
1. Nominal system voltage.
 2. Arc flash boundary (inches).
 3. Available arc flash incident energy at the corresponding working distance (calories/cm²).
 4. Required PPE category and description.
 5. Limited approach distance (inches), restricted approach distance (inches).
 6. Equipment/bus name, date prepared, and manufacturer name and address.
 7. For outdoor use, arc flash labels must be laminated, UV stable and weatherproof.

1.12 SUBMITTALS

- A. Submit to the COR in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
- B. The Government's approval shall be obtained for all materials and equipment before delivery to the job site. Delivery, storage or installation of materials and equipment which has not had prior approval will not be permitted.
- C. All submittals shall include six copies of adequate descriptive literature, catalog cuts, shop drawings, test reports, certifications, samples, and other data necessary for the Government to ascertain that the proposed materials and equipment comply with drawing and specification requirements. Catalog cuts submitted for approval shall be legible and clearly identify specific materials and equipment being submitted.

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- D. Submittals for individual systems and equipment assemblies which consist of more than one item or component shall be made for the system or assembly as a whole. Partial submittals will not be considered for approval.
1. Mark the submittals, "SUBMITTED UNDER SECTION 26 05 11".
 2. Submittals shall be marked to show specification reference including the section and paragraph numbers.
 3. Submit each section separately.
- E. The submittals shall include the following:
1. Information that confirms compliance with contract requirements. Include the manufacturer's name, model or catalog numbers, catalog information, technical data sheets, shop drawings, manuals, pictures, nameplate data, and test reports as required.
 2. Submittals are required for all equipment anchors and supports. Submittals shall include weights, dimensions, center of gravity, standard connections, manufacturer's recommendations and behavior problems (e.g., vibration, thermal expansion, etc.) associated with equipment or piping so that the proposed installation can be properly reviewed. Include sufficient fabrication information so that appropriate mounting and securing provisions may be designed and attached to the equipment.
 3. Elementary and interconnection wiring diagrams for communication and signal systems, control systems, and equipment assemblies. All terminal points and wiring shall be identified on wiring diagrams.
 4. Parts list which shall include information for replacement parts and ordering instructions, as recommended by the equipment manufacturer.
- F. Maintenance and Operation Manuals:
1. Submit as required for systems and equipment specified in the technical sections. Furnish in hardcover binders or an approved equivalent.
 2. Inscribe the following identification on the cover: the words "MAINTENANCE AND OPERATION MANUAL," the name and location of the system, material, equipment, building, name of Contractor, and contract name and number. Include in the manual the names, addresses, and telephone numbers of each subcontractor installing

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the system or equipment and the local representatives for the material or equipment.

3. Provide a table of contents and assemble the manual to conform to the table of contents, with tab sheets placed before instructions covering the subject. The instructions shall be legible and easily read, with large sheets of drawings folded in.
4. The manuals shall include:
 - a. Internal and interconnecting wiring and control diagrams with data to explain detailed operation and control of the equipment.
 - b. A control sequence describing start-up, operation, and shutdown.
 - c. Description of the function of each principal item of equipment.
 - d. Installation instructions.
 - e. Safety precautions for operation and maintenance.
 - f. Diagrams and illustrations.
 - g. Periodic maintenance and testing procedures and frequencies, including replacement parts numbers.
 - h. Performance data.
 - i. Pictorial "exploded" parts list with part numbers. Emphasis shall be placed on the use of special tools and instruments. The list shall indicate sources of supply, recommended spare and replacement parts, and name of servicing organization.
 - j. List of factory approved or qualified permanent servicing organizations for equipment repair and periodic testing and maintenance, including addresses and factory certification qualifications.
- G. Approvals will be based on complete submission of shop drawings, manuals, test reports, certifications, and samples as applicable.
- H. After approval and prior to installation, furnish the COR with one sample of each of the following:
 1. A minimum 300 mm (12 inches) length of each type and size of wire and cable along with the tag from the coils or reels from which the

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sample was taken. The length of the sample shall be sufficient to show all markings provided by the manufacturer.

2. Each type of conduit coupling, bushing, and termination fitting.
3. Conduit hangers, clamps, and supports.
4. Duct sealing compound.
5. Each type of receptacle, toggle switch, lighting control sensor, outlet box, manual motor starter, device wall plate, engraved nameplate, wire and cable splicing and terminating material, and branch circuit single pole molded case circuit breaker.

1.13 SINGULAR NUMBER

- A. Where any device or part of equipment is referred to in these specifications in the singular number (e.g., "the switch"), this reference shall be deemed to apply to as many such devices as are required to complete the installation as shown on the drawings.

1.14 ACCEPTANCE CHECKS AND TESTS

- A. The Contractor shall furnish the instruments, materials, and labor for tests.
- B. Where systems are comprised of components specified in more than one section of Division 26, the Contractor shall coordinate the installation, testing, and adjustment of all components between various manufacturer's representatives and technicians so that a complete, functional, and operational system is delivered to the Government.
- C. When test results indicate any defects, the Contractor shall repair or replace the defective materials or equipment, and repeat the tests. Repair, replacement, and retesting shall be accomplished at no additional cost to the Government.

1.15 WARRANTY

- A. All work performed and all equipment and material furnished under this Division shall be free from defects and shall remain so for a period of one year from the date of acceptance of the entire installation by the Contracting Officer for the Government.

1.16 INSTRUCTION

- A. Instruction to designated Government personnel shall be provided for the particular equipment or system as required in each associated technical specification section.

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B. Furnish the services of competent instructors to give full instruction in the adjustment, operation, and maintenance of the specified equipment and system, including pertinent safety requirements. Instructors shall be thoroughly familiar with all aspects of the installation, and shall be trained in operating theory as well as practical operation and maintenance procedures.

C. A training schedule shall be developed and submitted by the Contractor and approved by the COR at least 30 days prior to the planned training.

PART 2 - PART 2 - PRODUCTS (NOT USED)

PART 3 - PART 3 - EXECUTION (NOT USED)

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SECTION 26 05 19
LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, connection, and testing of the electrical conductors and cables for use in electrical systems rated 600 V and below, indicated as cable(s), conductor(s), wire, or wiring in this section.

1.2 RELATED WORK

- A. Section 07 84 00, FIRESTOPPING: Sealing around penetrations to maintain the integrity of fire-resistant rated construction.
- B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.
- C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
- D. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits for conductors and cables.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES), in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 FACTORY TESTS

- A. Conductors and cables shall be thoroughly tested at the factory per NEMA to ensure that there are no electrical defects. Factory tests shall be certified.

1.5 SUBMITTALS

- A. Submit the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
1. Shop Drawings:
 - a. Submit sufficient information to demonstrate compliance with drawings and specifications.
 - b. Submit the following data for approval:
 - 1) Electrical ratings and insulation type for each conductor and cable.
 - 2) Splicing materials and pulling lubricant.

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2. Certifications: Two weeks prior to final inspection, submit the following.

- a. Certification by the manufacturer that the conductors and cables conform to the requirements of the drawings and specifications.
- b. Certification by the Contractor that the conductors and cables have been properly installed, adjusted, and tested.

1.6 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent referenced. Publications are reference in the text by designation only.
- B. American Society of Testing Material (ASTM):
 - D2301-10.....Standard Specification for Vinyl Chloride
Plastic Pressure-Sensitive Electrical
Insulating Tape
 - D2304-10.....Test Method for Thermal Endurance of Rigid
Electrical Insulating Materials
 - D3005-10.....Low-Temperature Resistant Vinyl Chloride
Plastic Pressure-Sensitive Electrical
Insulating Tape
- C. National Electrical Manufacturers Association (NEMA):
 - WC 70-09.....Power Cables Rated 2000 Volts or Less for the
Distribution of Electrical Energy
- D. National Fire Protection Association (NFPA):
 - 70-14.....National Electrical Code (NEC)
- E. Underwriters Laboratories, Inc. (UL):
 - 44-10.....Thermoset-Insulated Wires and Cables
 - 83-08.....Thermoplastic-Insulated Wires and Cables
 - 467-07.....Grounding and Bonding Equipment
 - 486A-486B-03.....Wire Connectors
 - 486C-04.....Splicing Wire Connectors
 - 486D-05.....Sealed Wire Connector Systems
 - 486E-09.....Equipment Wiring Terminals for Use with
Aluminum and/or Copper Conductors
 - 493-07.....Thermoplastic-Insulated Underground Feeder and
Branch Circuit Cables

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514B-04.....Conduit, Tubing, and Cable Fittings

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

- A. Conductors and cables shall be in accordance with NEMA, UL, as specified herein, and as shown on the drawings.
- B. All conductors shall be copper.
- C. Single Conductor and Cable:
 - 1. No. 12 AWG: Minimum size, except where smaller sizes are specified herein or shown on the drawings.
 - 2. No. 8 AWG and larger: Stranded.
 - 3. No. 10 AWG and smaller: Solid; except shall be stranded for final connection to motors, transformers, and vibrating equipment.
 - 4. Insulation: THHN-THWN and XHHW-2. XHHW-2 shall be used for isolated power systems.
- D. Color Code:
 - 1. No. 10 AWG and smaller: Solid color insulation or solid color coating.
 - 2. No. 8 AWG and larger: Color-coded using one of the following methods:
 - a. Solid color insulation or solid color coating.
 - b. Stripes, bands, or hash marks of color specified.
 - c. Color using 19 mm (0.75 inches) wide tape.
 - 3. For modifications and additions to existing wiring systems, color coding shall conform to the existing wiring system.
 - 4. Conductors shall be color-coded as follows:

208/120 V	Phase	480/277 V
Black	A	Brown
Red	B	Orange
Blue	C	Yellow
White	Neutral	Gray *
* or white with colored (other than green) tracer.		

- 5. Lighting circuit "switch legs", and 3-way and 4-way switch "traveling wires," shall have color coding that is unique and distinct (e.g., pink and purple) from the color coding indicated

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above. The unique color codes shall be solid and in accordance with the NEC. Coordinate color coding in the field with the Contracting Officers Representative (COR).

6. Color code for isolated power system wiring shall be in accordance with the NEC.

2.2 SPLICES

- A. Splices shall be in accordance with NEC and UL.
- B. Above Ground Splices for No. 10 AWG and Smaller:
 1. Solderless, screw-on, reusable pressure cable type, with integral insulation, approved for copper and aluminum conductors.
 2. The integral insulator shall have a skirt to completely cover the stripped conductors.
 3. The number, size, and combination of conductors used with the connector, as listed on the manufacturer's packaging, shall be strictly followed.
- C. Above Ground Splices for No. 8 AWG to No. 4/0 AWG:
 1. Compression, hex screw, or bolt clamp-type of high conductivity and corrosion-resistant material, listed for use with copper and aluminum conductors.
 2. Insulate with materials approved for the particular use, location, voltage, and temperature. Insulation level shall be not less than the insulation level of the conductors being joined.
 3. Splice and insulation shall be product of the same manufacturer.
 4. All bolts, nuts, and washers used with splices shall be steel.
- D. Above Ground Splices for 250 kcmil and Larger:
 1. Long barrel "butt-splice" or "sleeve" type compression connectors, with minimum of two compression indents per wire, listed for use with copper and aluminum conductors.
 2. Insulate with materials approved for the particular use, location, voltage, and temperature. Insulation level shall be not less than the insulation level of the conductors being joined.
 3. Splice and insulation shall be product of the same manufacturer.
- E. Plastic electrical insulating tape: Per ASTM D2304, flame-retardant, cold and weather resistant.

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2.3 CONNECTORS AND TERMINATIONS

- A. Mechanical type of high conductivity and corrosion-resistant material, listed for use with copper and aluminum conductors.
- B. Long barrel compression type of high conductivity and corrosion-resistant material, with minimum of two compression indents per wire, listed for use with copper and aluminum conductors.
- C. All bolts, nuts, and washers used to connect connections and terminations to bus bars or other termination points shall be steel.

2.4 CONTROL WIRING

- A. Unless otherwise specified elsewhere in these specifications, control wiring shall be as specified herein, except that the minimum size shall be not less than No. 14 AWG.
- B. Control wiring shall be sized such that the voltage drop under in-rush conditions does not adversely affect operation of the controls.

2.5 WIRE LUBRICATING COMPOUND

- A. Lubricating compound shall be suitable for the wire insulation and conduit, and shall not harden or become adhesive.
- B. Shall not be used on conductors for isolated power systems.

PART 3 - EXECUTION

3.1 GENERAL

- A. Install conductors in accordance with the NEC, as specified, and as shown on the drawings.
- B. Install all conductors in raceway systems.
- C. Splice conductors only in outlet boxes, junction boxes, and pullboxes.
- C. Conductors of different systems (e.g., 120 V and 277 V) shall not be installed in the same raceway.
- D. Install cable supports for all vertical feeders in accordance with the NEC. Provide split wedge type which firmly clamps each individual cable and tightens due to cable weight.
- E. In panelboards, cabinets, wireways, switches, enclosures, and equipment assemblies, neatly form, train, and tie the conductors with non-metallic ties.
- F. For connections to motors, transformers, and vibrating equipment, stranded conductors shall be used only from the last fixed point of connection to the motors, transformers, or vibrating equipment.

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G. Use expanding foam or non-hardening duct-seal to seal conduits entering a building, after installation of conductors.

H. Conductor and Cable Pulling:

1. Provide installation equipment that will prevent the cutting or abrasion of insulation during pulling. Use lubricants approved for the cable.
2. Use nonmetallic pull ropes.
3. Attach pull ropes by means of either woven basket grips or pulling eyes attached directly to the conductors.
4. All conductors in a single conduit shall be pulled simultaneously.
5. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

I. No more than three branch circuits shall be installed in any one conduit.

J. When stripping stranded conductors, use a tool that does not damage the conductor or remove conductor strands.

3.2 SPLICE AND TERMINATION INSTALLATION

A. Splices and terminations shall be mechanically and electrically secure, and tightened to manufacturer's published torque values using a torque screwdriver or wrench.

B. Where the Government determines that unsatisfactory splices or terminations have been installed, replace the splices or terminations at no additional cost to the Government.

3.3 CONDUCTOR IDENTIFICATION

A. When using colored tape to identify phase, neutral, and ground conductors larger than No. 8 AWG, apply tape in half-overlapping turns for a minimum of 75 mm (3 inches) from terminal points, and in junction boxes and pullboxes. Apply the last two laps of tape with no tension to prevent possible unwinding. Where cable markings are covered by tape, apply tags to cable, stating size and insulation type.

3.4 FEEDER CONDUCTOR IDENTIFICATION

A. In each interior pullbox install brass tags on all feeder conductors to clearly designate their circuit identification and voltage. The tags shall be the embossed type, 40 mm (1-1/2 inches) in diameter and 40 mils thick. Attach tags with plastic ties.

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3.5 EXISTING CONDUCTORS

- A. Unless specifically indicated on the plans, existing conductors shall not be reused.

3.6 CONTROL WIRING INSTALLATION

- A. Unless otherwise specified in other sections, install control wiring and connect to equipment to perform the required functions as specified or as shown on the drawings.
- B. Install a separate power supply circuit for each system, except where otherwise shown on the drawings.

3.7 CONTROL WIRING IDENTIFICATION

- A. Install a permanent wire marker on each wire at each termination.
- B. Identifying numbers and letters on the wire markers shall correspond to those on the wiring diagrams used for installing the systems.
- C. Wire markers shall retain their markings after cleaning.

3.8 ACCEPTANCE CHECKS AND TESTS

- A. Perform in accordance with the manufacturer's recommendations. In addition, include the following:
 - 1. Visual Inspection and Tests: Inspect physical condition.
 - 2. Electrical tests:
 - a. After installation but before connection to utilization devices, such as fixtures, motors, or appliances, test conductors phase-to-phase and phase-to-ground resistance with an insulation resistance tester. Existing conductors to be reused shall also be tested.
 - b. Applied voltage shall be 500 V DC for 300 V rated cable, and 1000 V DC for 600 V rated cable. Apply test for one minute or until reading is constant for 15 seconds, whichever is longer. Minimum insulation resistance values shall not be less than 25 megohms for 300 V rated cable and 100 megohms for 600 V rated cable.
 - c. Perform phase rotation test on all three-phase circuits.

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SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, connection, and testing of grounding and bonding equipment, indicated as grounding equipment in this section.
- B. "Grounding electrode system" refers to grounding electrode conductors and all electrodes required or allowed by NEC, as well as made, supplementary, and lightning protection system grounding electrodes.
- C. The terms "connect" and "bond" are used interchangeably in this section and have the same meaning.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.
- B. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Low-voltage conductors.
- C. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduit and boxes.
- D. Section 26 24 16, PANELBOARDS: Low-voltage panelboards.
- E. Section 26 24 19, MOTOR CONTROL CENTERS: Motor control centers.
- F. Section 26 41 00, FACILITY LIGHTNING PROTECTION: Lightning protection.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES), in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. Submit the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
 - 1. Shop Drawings:
 - a. Submit sufficient information to demonstrate compliance with drawings and specifications.
 - b. Submit plans showing the location of system grounding electrodes and connections, and the routing of aboveground.
 - 2. Test Reports:

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- a. Two weeks prior to the final inspection, submit ground resistance field test reports to the Contracting Officers Representative (COR).

3. Certifications:

- a. Certification by the Contractor that the grounding equipment has been properly installed and tested.

1.5 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. American Society for Testing and Materials (ASTM):
 - B1-07.....Standard Specification for Hard-Drawn Copper Wire
 - B3-07.....Standard Specification for Soft or Annealed Copper Wire
 - B8-11.....Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
- C. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
 - 81-83.....IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System Part 1: Normal Measurements
- D. National Fire Protection Association (NFPA):
 - 70-14.....National Electrical Code (NEC)
 - 70E-12.....National Electrical Safety Code
 - 99-12.....Health Care Facilities
- E. Underwriters Laboratories, Inc. (UL):
 - 44-10Thermoset-Insulated Wires and Cables
 - 83-08Thermoplastic-Insulated Wires and Cables
 - 467-07Grounding and Bonding Equipment

PART 2 - PRODUCTS

1.6 GROUNDING AND BONDING CONDUCTORS

- A. Equipment grounding conductors shall be insulated stranded copper, except that sizes No. 10 AWG and smaller shall be solid copper. Insulation color shall be continuous green for all equipment grounding

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conductors, except that wire sizes No. 4 AWG and larger shall be identified per NEC.

- B. Bonding conductors shall be bare stranded copper, except that sizes No. 10 AWG and smaller shall be bare solid copper. Bonding conductors shall be stranded for final connection to motors, transformers, and vibrating equipment.
- C. Conductor sizes shall not be less than shown on the drawings, or not less than required by the NEC, whichever is greater.
- D. Insulation: THHN-THWN and XHHW-2. XHHW-2 shall be used for isolated power systems.

1.7 GROUND CONNECTIONS

- A. Above Grade:
 - 1. Bonding Jumpers: Listed for use with aluminum and copper conductors. For wire sizes No. 8 AWG and larger, use compression-type connectors. For wire sizes smaller than No. 8 AWG, use mechanical type lugs. Connectors or lugs shall use zinc-plated steel bolts, nuts, and washers. Bolts shall be torqued to the values recommended by the manufacturer.
 - 2. Connection to Building Steel: Exothermic-welded type connectors.
 - 3. Connection to Grounding Bus Bars: Listed for use with aluminum and copper conductors. Use mechanical type lugs, with zinc-plated steel bolts, nuts, and washers. Bolts shall be torqued to the values recommended by the manufacturer.

1.8 GROUNDING BUS BAR

- A. Pre-drilled rectangular copper bar with stand-off insulators, minimum 6.3 mm (0.25 inch) thick x 100 mm (4 inches) high in cross-section, length as shown on the drawings, with hole size, quantity, and spacing per detail shown on the drawings. Provide insulators and mounting brackets.

PART 2 - EXECUTION

2.1 GENERAL

- A. Install grounding equipment in accordance with the NEC, as shown on the drawings, and as specified herein.
- B. Lightning Arresters: Connect lightning arresters to the equipment ground bus or ground rods as applicable.

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2.2 SECONDARY VOLTAGE EQUIPMENT AND CIRCUITS

- A. Main Bonding Jumper: Bond the secondary service neutral to the ground bus in the service equipment.
- B. Metallic Piping, Building Structural Steel, and Supplemental Electrode(s):
 - 1. Provide a grounding electrode conductor sized per NEC between the service equipment ground bus and all metallic water pipe systems, building structural steel, and supplemental or made electrodes. Provide jumpers across insulating joints in the metallic piping.
 - 2. Provide a supplemental ground electrode as shown on the drawings and bond to the grounding electrode system.
- C. Panelboards, Motor Control Centers, and other electrical equipment:
 - 1. Connect the equipment grounding conductors to the ground bus.
 - 2. Connect metallic conduits by grounding bushings and equipment grounding conductor to the equipment ground bus.

2.3 RACEWAY

- A. Conduit Systems:
 - 1. Ground all metallic conduit systems. All metallic conduit systems shall contain an equipment grounding conductor.
 - 2. Non-metallic conduit systems, except non-metallic feeder conduits that carry a grounded conductor from exterior transformers to interior or building-mounted service entrance equipment, shall contain an equipment grounding conductor.
 - 3. Metallic conduit that only contains a grounding conductor, and is provided for its mechanical protection, shall be bonded to that conductor at the entrance and exit from the conduit.
 - 4. Metallic conduits which terminate without mechanical connection to an electrical equipment housing by means of locknut and bushings or adapters, shall be provided with grounding bushings. Connect bushings with a equipment grounding conductor to the equipment ground bus.
- B. Feeders and Branch Circuits: Install equipment grounding conductors with all feeders, and power and lighting branch circuits.
- C. Boxes, Cabinets, Enclosures, and Panelboards:
 - 1. Bond the equipment grounding conductor to each pullbox, junction box, outlet box, device box, cabinets, and other enclosures through

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which the conductor passes (except for special grounding systems for intensive care units and other critical units shown).

2. Provide lugs in each box and enclosure for equipment grounding conductor termination.

D. Wireway Systems:

1. Bond the metallic structures of wireway to provide electrical continuity throughout the wireway system, by connecting a No. 6 AWG bonding jumper at all intermediate metallic enclosures and across all section junctions.
2. Install insulated No. 6 AWG bonding jumpers between the wireway system, bonded as required above, and the closest building ground at each end and approximately every 16 M (50 feet).
3. Use insulated No. 6 AWG bonding jumpers to ground or bond metallic wireway at each end for all intermediate metallic enclosures and across all section junctions.
4. Use insulated No. 6 AWG bonding jumpers to ground cable tray to column-mounted building ground plates (pads) at each end and approximately every 15 M (49 feet).

E. Receptacles shall not be grounded through their mounting screws. Ground receptacles with a jumper from the receptacle green ground terminal to the device box ground screw and a jumper to the branch circuit equipment grounding conductor.

F. Ground lighting fixtures to the equipment grounding conductor of the wiring system. Fixtures connected with flexible conduit shall have a green ground wire included with the power wires from the fixture through the flexible conduit to the first outlet box.

G. Fixed electrical appliances and equipment shall be provided with a ground lug for termination of the equipment grounding conductor.

3.6 CORROSION INHIBITORS

- A. When making grounding and bonding connections, apply a corrosion inhibitor to all contact surfaces. Use corrosion inhibitor appropriate for protecting a connection between the metals used.

3.7 CONDUCTIVE PIPING

- A. Bond all conductive piping systems, interior and exterior, to the grounding electrode system. Bonding connections shall be made as close as practical to the equipment ground bus.

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3.8 LIGHTNING PROTECTION SYSTEM

- A. Bond the lightning protection system to the electrical grounding electrode system.

3.9 MAIN ELECTRICAL ROOM GROUNDING

- A. Provide ground bus bar and mounting hardware at each main electrical room where incoming feeders are terminated, as shown on the drawings. Connect to pigtail extensions of the building grounding ring, as shown on the drawings.

3.10 GROUND RESISTANCE

- A. Grounding system resistance to ground shall not exceed 5 ohms. Make any modifications or additions to the grounding electrode system necessary for compliance without additional cost to the Government. Final tests shall ensure that this requirement is met.
- B. Grounding system resistance shall comply with the electric utility company ground resistance requirements.

3.11 ACCEPTANCE CHECKS AND TESTS

- A. Resistance of the grounding electrode system shall be measured using a four-terminal fall-of-potential method as defined in IEEE 81. Ground resistance measurements shall be made before the electrical distribution system is energized or connected to the electric utility company ground system, and shall be made in normally dry conditions not fewer than 48 hours after the last rainfall.
- B. Resistance measurements of separate grounding electrode systems shall be made before the systems are bonded together. The combined resistance of separate systems may be used to meet the required resistance, but the specified number of electrodes must still be provided.
- C. Below-grade connections shall be visually inspected by the COR prior to backfilling. The Contractor shall notify the COR 24 hours before the connections are ready for inspection.

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SECTION 26 05 33

RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, and connection of conduit, fittings, and boxes, to form complete, coordinated, grounded raceway systems. Raceways are required for all wiring unless shown or specified otherwise.
- B. Definitions: The term conduit, as used in this specification, shall mean any or all of the raceway types specified.

1.2 RELATED WORK

- A. Section 07 60 00, FLASHING AND SHEET METAL: Fabrications for the deflection of water away from the building envelope at penetrations.
- B. Section 07 84 00, FIRESTOPPING: Sealing around penetrations to maintain the integrity of fire rated construction.
- C. Section 07 92 00, JOINT SEALANTS: Sealing around conduit penetrations through the building envelope to prevent moisture migration into the building.
- D. Section 09 91 00, PAINTING: Identification and painting of conduit and other devices.
- E. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements and items that are common to more than one section of Division 26.
- F. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. Submit six copies of the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
 - 1. Shop Drawings:
 - a. Size and location of main feeders.
 - b. Size and location of panels and pull-boxes.

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- c. Layout of required conduit penetrations through structural elements.
- d. Submit the following data for approval:
 - 1) Raceway types and sizes.
 - 2) Conduit bodies, connectors and fittings.
 - 3) Junction and pull boxes, types and sizes.
- 2. Certifications: Two weeks prior to final inspection, submit the following:
 - a. Certification by the manufacturer that raceways, conduits, conduit bodies, connectors, fittings, junction and pull boxes, and all related equipment conform to the requirements of the drawings and specifications.
 - b. Certification by the Contractor that raceways, conduits, conduit bodies, connectors, fittings, junction and pull boxes, and all related equipment have been properly installed.

1.5 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. American National Standards Institute (ANSI):
 - C80.1-05.....Electrical Rigid Steel Conduit
 - C80.3-05.....Steel Electrical Metal Tubing
 - C80.6-05.....Electrical Intermediate Metal Conduit
- C. National Fire Protection Association (NFPA):
 - 70-14.....National Electrical Code (NEC)
- D. Underwriters Laboratories, Inc. (UL):
 - 1-05.....Flexible Metal Conduit
 - 5-11.....Surface Metal Raceway and Fittings
 - 6-07.....Electrical Rigid Metal Conduit - Steel
 - 50-95.....Enclosures for Electrical Equipment
 - 360-13.....Liquid-Tight Flexible Steel Conduit
 - 467-13.....Grounding and Bonding Equipment
 - 514A-13.....Metallic Outlet Boxes
 - 514B-12.....Conduit, Tubing, and Cable Fittings

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- 514C-07.....Nonmetallic Outlet Boxes, Flush-Device Boxes
and Covers
- 651-11.....Schedule 40 and 80 Rigid PVC Conduit and
Fittings
- 651A-11.....Type EB and A Rigid PVC Conduit and HDPE
Conduit
- 797-07.....Electrical Metallic Tubing
- 1242-06.....Electrical Intermediate Metal Conduit - Steel
- E. National Electrical Manufacturers Association (NEMA):
- TC-2-13.....Electrical Polyvinyl Chloride (PVC) Tubing and
Conduit
- TC-3-13.....PVC Fittings for Use with Rigid PVC Conduit and
Tubing
- FB1-12.....Fittings, Cast Metal Boxes and Conduit Bodies
for Conduit, Electrical Metallic Tubing and
Cable
- FB2.10-13.....Selection and Installation Guidelines for
Fittings for use with Non-Flexible Conduit or
Tubing (Rigid Metal Conduit, Intermediate
Metallic Conduit, and Electrical Metallic
Tubing)
- FB2.20-12.....Selection and Installation Guidelines for
Fittings for use with Flexible Electrical
Conduit and Cable
- F. American Iron and Steel Institute (AISI):
- S100-2007.....North American Specification for the Design of
Cold-Formed Steel Structural Members

PART 2 - PRODUCTS

2.1 MATERIAL

- A. Conduit Size: In accordance with the NEC, but not less than 0.75-inch unless otherwise shown. Where permitted by the NEC, 0.75-inch flexible conduit may be used for tap connections to recessed lighting fixtures.
- B. Conduit:
1. Size: In accordance with the NEC, but not less than 0.75-inch.
 2. Rigid Steel Conduit (RMC): Shall conform to UL 6 and ANSI C80.1.

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3. Rigid Intermediate Steel Conduit (IMC): Shall conform to UL 1242 and ANSI C80.6.
4. Electrical Metallic Tubing (EMT): Shall conform to UL 797 and ANSI C80.3. Maximum size not to exceed 4 inches and shall be permitted only with cable rated 600 V or less.
5. Flexible Metal Conduit: Shall conform to UL 1.
6. Liquid-tight Flexible Metal Conduit: Shall conform to UL 360.
7. Surface Metal Raceway: Shall conform to UL 5.

C. Conduit Fittings:

1. Rigid Steel and Intermediate Metallic Conduit Fittings:
 - a. Fittings shall meet the requirements of UL 514B and NEMA FB1.
 - b. Standard threaded couplings, locknuts, bushings, conduit bodies, and elbows: Only steel or malleable iron materials are acceptable. Integral retractable type IMC couplings are also acceptable.
 - c. Locknuts: Bonding type with sharp edges for digging into the metal wall of an enclosure.
 - d. Bushings: Metallic insulating type, consisting of an insulating insert, molded or locked into the metallic body of the fitting. Bushings made entirely of metal or nonmetallic material are not permitted.
 - e. Erickson (Union-Type) and Set Screw Type Couplings: Approved for use in concrete are permitted for use to complete a conduit run where conduit is installed in concrete. Use set screws of case-hardened steel with hex head and cup point to firmly seat in conduit wall for positive ground. Tightening of set screws with pliers is prohibited.
 - f. Sealing Fittings: Threaded cast iron type. Use continuous drain-type sealing fittings to prevent passage of water vapor. In concealed work, install fittings in flush steel boxes with blank cover plates having the same finishes as that of other electrical plates in the room.
2. Electrical Metallic Tubing Fittings:
 - a. Fittings and conduit bodies shall meet the requirements of UL 514B, ANSI C80.3, and NEMA FB1.
 - b. Only steel or malleable iron materials are acceptable.

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- c. Compression Couplings and Connectors: Concrete-tight and rain-tight, with connectors having insulated throats.
 - d. Indent-type connectors or couplings are prohibited.
 - e. Die-cast or pressure-cast zinc-alloy fittings or fittings made of "pot metal" are prohibited.
- 3. Flexible Metal Conduit Fittings:
 - a. Conform to UL 514B. Only steel or malleable iron materials are acceptable.
 - b. Clamp-type, with insulated throat.
- 4. Liquid-tight Flexible Metal Conduit Fittings:
 - a. Fittings shall meet the requirements of UL 514B and NEMA FB1.
 - b. Only steel or malleable iron materials are acceptable.
 - c. Fittings must incorporate a threaded grounding cone, a steel or plastic compression ring, and a gland for tightening.
Connectors shall have insulated throats.
- 5. Surface Metal Raceway Fittings: As recommended by the raceway manufacturer. Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, conduit entry fittings, accessories, and other fittings as required for complete system.
- 6. Expansion and Deflection Couplings:
 - a. Conform to UL 467 and UL 514B.
 - b. Accommodate a 19 mm (0.75-inch) deflection, expansion, or contraction in any direction, and allow 30 degree angular deflections.
 - c. Include internal flexible metal braid, sized to guarantee conduit ground continuity and a low-impedance path for fault currents, in accordance with UL 467 and the NEC tables for equipment grounding conductors.
 - d. Jacket: Flexible, corrosion-resistant, watertight, moisture and heat-resistant molded rubber material with stainless steel jacket clamps.
- D. Conduit Supports:
 - 1. Parts and Hardware: Zinc-coat or provide equivalent corrosion protection.

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2. Individual Conduit Hangers: Designed for the purpose, having a pre-assembled closure bolt and nut, and provisions for receiving a hanger rod.
 3. Multiple Conduit (Trapeze) Hangers: Not less than 38 mm x 38 mm (1.5 x 1.5 inches), 12-gauge steel, cold-formed, lipped channels; with not less than 9 mm (0.375-inch) diameter steel hanger rods.
 4. Solid Masonry and Concrete Anchors: Self-drilling expansion shields, or machine bolt expansion.
- E. Outlet, Junction, and Pull Boxes:
1. UL-50 and UL-514A.
 2. Rustproof cast metal where required by the NEC or shown on drawings.
 3. Sheet Metal Boxes: Galvanized steel, except where shown on drawings.
- F. Metal Wireways: Equip with hinged covers, except as shown on drawings. Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for a complete system.

PART 3 - EXECUTION

3.1 PENETRATIONS

- A. Cutting or Holes:
1. Cut holes in advance where they should be placed in the structural elements, such as ribs or beams. Obtain the approval of COR prior to drilling through structural elements.
 2. Cut holes through concrete and masonry in new and existing structures with a diamond core drill or concrete saw. Pneumatic hammers, impact electric, hand, or manual hammer-type drills are not allowed, except when permitted by the COR where working space is limited.
- B. Firestop: Where conduits, wireways, and other electrical raceways pass through fire partitions, fire walls, smoke partitions, or floors, install a fire stop that provides an effective barrier against the spread of fire, smoke and gases as specified in Section 07 84 00, FIRESTOPPING.
- C. Waterproofing: At floor, exterior wall, and roof conduit penetrations, completely seal the gap around conduit to render it watertight, as specified in Section 07 92 00, JOINT SEALANTS.

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3.2 INSTALLATION, GENERAL

- A. In accordance with UL, NEC, NEMA, as shown on drawings, and as specified herein.
- B. Install conduit as follows:
 - 1. In complete mechanically and electrically continuous runs before pulling in cables or wires.
 - 2. Unless otherwise indicated on the drawings or specified herein, installation of all conduits shall be concealed within finished walls and ceilings.
 - 3. Flattened, dented, or deformed conduit is not permitted. Remove and replace the damaged conduits with new conduits.
 - 4. Assure conduit installation does not encroach into the ceiling height head room, walkways, or doorways.
 - 5. Cut conduits square, ream, remove burrs, and draw up tight.
 - 6. Independently support conduit at 2.4 M (8 feet) on centers with specified materials and as shown on drawings.
 - 7. Do not use suspended ceilings, suspended ceiling supporting members, lighting fixtures, other conduits, cable tray, boxes, piping, or ducts to support conduits and conduit runs.
 - 8. Support within 300 mm (12 inches) of changes of direction, and within 300 mm (12 inches) of each enclosure to which connected.
 - 9. Close ends of empty conduits with plugs or caps at the rough-in stage until wires are pulled in, to prevent entry of debris.
 - 10. Conduit installations under fume and vent hoods are prohibited.
 - 11. Secure conduits to cabinets, junction boxes, pull-boxes, and outlet boxes with bonding type locknuts. For rigid steel and IMC conduit installations, provide a locknut on the inside of the enclosure, made up wrench tight. Do not make conduit connections to junction box covers.
 - 12. Flashing of penetrations of the roof membrane is specified in Section 07 60 00, FLASHING AND SHEET METAL.
 - 13. Conduit bodies shall only be used for changes in direction, and shall not contain splices.
 - 14. Do not use aluminum conduits in wet locations.
- C. Conduit Bends:
 - 1. Make bends with standard conduit bending machines.

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2. Conduit hickey may be used for slight offsets and for straightening stubbed out conduits.

3. Bending of conduits with a pipe tee or vise is prohibited.

D. Layout and Homeruns:

1. Install conduit with wiring, including homeruns, as shown on drawings.

2. Deviations: Make only where necessary to avoid interferences and only after drawings showing the proposed deviations have been submitted and approved by the COR.

3.3 CONCEALED WORK INSTALLATION

A. In Concrete:

1. Conduit: Rigid steel, IMC, or EMT. Do not install EMT in concrete slabs that are in contact with soil, gravel, or vapor barriers.

2. Align and run conduit in direct lines.

3. Install conduit through concrete beams only:

a. Where shown on the structural drawings.

b. As approved by the COR prior to construction, and after submittal of drawing showing location, size, and position of each penetration.

4. Installation of conduit in concrete that is less than 75 mm (3 inches) thick is prohibited.

a. Conduit outside diameter larger than one-third of the slab thickness is prohibited.

b. Space between conduits in slabs: Approximately six conduit diameters apart, and one conduit diameter at conduit crossings.

c. Install conduits approximately in the center of the slab so that there will be a minimum of 19 mm (0.75-inch) of concrete around the conduits.

5. Make couplings and connections watertight. Use thread compounds that are UL approved conductive type to ensure low resistance ground continuity through the conduits. Tightening setscrews with pliers is prohibited.

B. Above Furred or Suspended Ceilings and in Walls:

1. Conduit for Conductors 600 V and Below: Rigid steel, IMC, or EMT.

Mixing different types of conduits in the same system is prohibited.

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2. Align and run conduit parallel or perpendicular to the building lines.
3. Connect recessed lighting fixtures to conduit runs with maximum 1.8 M (6 feet) of flexible metal conduit extending from a junction box to the fixture.
4. Tightening set screws with pliers is prohibited.
5. For conduits running through metal studs, limit field cut holes to no more than 70% of web depth. Spacing between holes shall be at least 18 inches. Cuts or notches in flanges or return lips shall not be permitted.

3.4 EXPOSED WORK INSTALLATION

- A. Unless otherwise indicated on drawings, exposed conduit is only permitted in mechanical and electrical rooms.
- B. Conduit for Conductors 600 V and Below: Rigid steel, IMC, or EMT. Mixing different types of conduits in the system is prohibited.
- C. Align and run conduit parallel or perpendicular to the building lines.
- D. Install horizontal runs close to the ceiling or beams and secure with conduit straps.
- E. Support horizontal or vertical runs at not over 2.4 M (8 feet) intervals.
- F. Surface Metal Raceways: Use only where shown on drawings.
- G. Painting:
 1. Paint exposed conduit as specified in Section 09 91 00, PAINTING.

3.5 WET OR DAMP LOCATIONS

- A. Use rigid steel or IMC conduits unless as shown on drawings.
- B. Provide sealing fittings to prevent passage of water vapor where conduits pass from warm to cold locations, i.e., refrigerated spaces, constant-temperature rooms, air-conditioned spaces, building exterior walls, roofs, or similar spaces.
- C. Use rigid steel or IMC conduit within 1.5 M (5 feet) of the exterior and below concrete building slabs in contact with soil, gravel, or vapor barriers, unless as shown on drawings. Conduit shall be half-lapped with 10 mil PVC tape before installation. After installation, completely recoat or retape any damaged areas of coating.
- D. Conduits run on roof shall be supported with integral galvanized lipped steel channel, attached to UV-inhibited polycarbonate or polypropylene

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blocks every 2.4 M (8 feet) with 9 mm (3/8-inch) galvanized threaded rods, square washer and locknut. Conduits shall be attached to steel channel with conduit clamps.

3.6 MOTORS AND VIBRATING EQUIPMENT

- A. Use flexible metal conduit for connections to motors and other electrical equipment subject to movement, vibration, misalignment, cramped quarters, or noise transmission.
- B. Use liquid-tight flexible metal conduit for installation in exterior locations, moisture or humidity laden atmosphere, corrosive atmosphere, water or spray wash-down operations, inside airstream of HVAC units, and locations subject to seepage or dripping of oil, grease, or water.
- C. Provide a green equipment grounding conductor with flexible and liquid-tight flexible metal conduit.

3.7 EXPANSION JOINTS

- A. Conduits 75 mm (3 inch) and larger that are secured to the building structure on opposite sides of a building expansion joint require expansion and deflection couplings. Install the couplings in accordance with the manufacturer's recommendations.
- B. Provide conduits smaller than 75 mm (3 inch) with junction boxes on both sides of the expansion joint. Connect flexible metal conduits to junction boxes with sufficient slack to produce a 125 mm (5 inch) vertical drop midway between the ends of the flexible metal conduit. Flexible metal conduit shall have a green insulated copper bonding jumper installed. In lieu of this flexible metal conduit, expansion and deflection couplings as specified above are acceptable.
- C. Install expansion and deflection couplings where shown.

3.8 CONDUIT SUPPORTS

- A. Safe working load shall not exceed one-quarter of proof test load of fastening devices.
- B. Use pipe straps or individual conduit hangers for supporting individual conduits.
- C. Support multiple conduit runs with trapeze hangers. Use trapeze hangers that are designed to support a load equal to or greater than the sum of the weights of the conduits, wires, hanger itself, and an additional 90 kg (200 lbs). Attach each conduit with U-bolts or other approved fasteners.

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- D. Support conduit independently of junction boxes, pull-boxes, fixtures, suspended ceiling T-bars, angle supports, and similar items.
- E. Fasteners and Supports in Solid Masonry and Concrete:
 - 1. New Construction: Use steel or malleable iron concrete inserts set in place prior to placing the concrete.
 - 2. Existing Construction:
 - a. Steel expansion anchors not less than 6 mm (0.25-inch) bolt size and not less than 28 mm (1.125 inch) in embedment.
 - b. Power set fasteners not less than 6 mm (0.25-inch) diameter with depth of penetration not less than 75 mm (3 inch).
 - c. Use vibration and shock-resistant anchors and fasteners for attaching to concrete ceilings.
- F. Hollow Masonry: Toggle bolts.
- G. Bolts supported only by plaster or gypsum wallboard are not acceptable.
- H. Metal Structures: Use machine screw fasteners or other devices specifically designed and approved for the application.
- I. Attachment by wood plugs, rawl plug, plastic, lead or soft metal anchors, or wood blocking and bolts supported only by plaster is prohibited.
- J. Chain, wire, or perforated strap shall not be used to support or fasten conduit.
- K. Spring steel type supports or fasteners are prohibited for all uses except horizontal and vertical supports/fasteners within walls.
- L. Vertical Supports: Vertical conduit runs shall have riser clamps and supports in accordance with the NEC and as shown. Provide supports for cable and wire with fittings that include internal wedges and retaining collars.

3.9 BOX INSTALLATION

- A. Boxes for Concealed Conduits:
 - 1. Flush-mounted.
 - 2. Provide raised covers for boxes to suit the wall or ceiling, construction, and finish.
- B. In addition to boxes shown, install additional boxes where needed to prevent damage to cables and wires during pulling-in operations or where more than the equivalent of 4-90 degree bends are necessary.

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- C. Locate pullboxes so that covers are accessible and easily removed. Coordinate locations with piping and ductwork where installed above ceilings.
- D. Remove only knockouts as required. Plug unused openings. Use threaded plugs for cast metal boxes and snap-in metal covers for sheet metal boxes.
- E. Outlet boxes mounted back-to-back in the same wall are prohibited. A minimum 600 mm (24 inch) center-to-center lateral spacing shall be maintained between boxes.
- F. Flush-mounted wall or ceiling boxes shall be installed with raised covers so that the front face of raised cover is flush with the wall. Surface-mounted wall or ceiling boxes shall be installed with surface-style flat or raised covers.
- G. Minimum size of outlet boxes for ground fault circuit interrupter (GFCI) receptacles is 100 mm (4 inches) square x 55 mm (2.125 inches) deep, with device covers for the wall material and thickness involved.
- H. Stencil or install phenolic nameplates on covers of the boxes identified on riser diagrams; for example "SIG-FA JB No. 1."
- I. On all branch circuit junction box covers, identify the circuits with black marker.

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SECTION 26 08 00

COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. The requirements of this Section apply to all sections of Division 26.
- B. This project will have selected building systems commissioned. The complete list of equipment and systems to be commissioned 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 the Facility electrical systems, related subsystems and related equipment. This Section supplements the general requirements specified in Section 01 91 00 General Commissioning Requirements.
- B. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for more details regarding processes and procedures as well as roles and responsibilities for all Commissioning Team members.

1.4 DEFINITIONS

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

1.5 COMMISSIONED SYSTEMS

- A. Commissioning of a system or systems specified in Division 26 is part of the construction process. Documentation and testing of these systems, as well as training of the VA's Operation and Maintenance personnel in accordance with the requirements of Section 01 91 00 and of Division 26, is required in cooperation with the VA and the CxA.
- B. The Facility electrical systems commissioning will include the systems listed in Section 01 91 00 General Commissioning Requirements:

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1.6 SUBMITTALS

- A. The commissioning process requires review of selected Submittals. The CxA will provide a list of submittals that will be reviewed by the CxA. This list will be reviewed and approved by the Contracting Officers Representative (COR) prior to forwarding to the Contractor. Refer to Section 01 33 23 SHOP DRAWINGS, PRODUCT DATA, and SAMPLES for further details.
- B. The commissioning process requires Submittal review simultaneously with engineering review. Specific submittal requirements related to the commissioning process are specified in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 CONSTRUCTION INSPECTIONS

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

3.2 PRE-FUNCTIONAL CHECKLISTS

- A. The Contractor shall complete Pre-Functional Checklists to verify systems, subsystems, and equipment installation is complete and systems are ready for Systems Functional Performance Testing. The CxA 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 CxA for review. The CxA may spot check a sample of completed checklists. If the CxA determines that the information provided on the checklist is not accurate, the CxA will return the marked-up checklist to the Contractor for correction and resubmission. If the CxA determines that a significant number of completed checklists for similar equipment are not accurate, the CxA will select a broader sample of checklists for review. If the CxA 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

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resubmission. Refer to SECTION 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for submittal requirements for Pre-Functional Checklists, Equipment Startup Reports, and other commissioning documents.

3.3 CONTRACTORS TESTS

- A. Contractor tests as required by other sections of Division 26 shall be scheduled and documented in accordance with Section 01 00 00 GENERAL REQUIREMENTS. All testing shall be incorporated into the project schedule. Contractor shall provide no less than 7 calendar days' notice of testing. The CxA will witness selected Contractor tests at the sole discretion of the CxA. 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 CxA 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 CxA 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's operation and maintenance personnel is required in cooperation with the COR and CxA. Provide competent, factory authorized personnel to provide instruction to operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. 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 26 Sections for additional Contractor training requirements.

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SECTION 26 09 23
LIGHTING CONTROLS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation and connection of the lighting controls.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General requirements that are common to more than one section of Division 26.
- B. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Cables and wiring.
- C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path to ground for possible ground fault currents.
- D. Section 26 24 16, PANELBOARDS: panelboard enclosure and interior bussing used for lighting control panels.
- E. Section 26 27 26, WIRING DEVICES: Wiring devices used for control of the lighting systems.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES), in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. Submit the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
 - 1. Shop Drawings:
 - a. Submit the following information for each type of lighting controls.
 - b. Material and construction details.
 - c. Physical dimensions and description.
 - d. Wiring schematic and connection diagram.
 - e. Installation details.
 - 2. Manuals:
 - a. Submit, simultaneously with the shop drawings, complete maintenance and operating manuals, including technical data sheets, wiring diagrams, and information for ordering replacement parts.

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- b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
- 3. Certifications: Two weeks prior to final inspection, submit the following.
 - a. Certification by the Contractor that the lighting control systems have been properly installed and tested.

1.5 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. Green Seal (GS):
 - GC-12-03.....Occupancy Sensors
- C. National Electrical Manufacturer's Association (NEMA):
 - C136.10-10.....American National Standard for Roadway and Area Lighting Equipment—Locking-Type Photocontrol Devices and Mating Receptacles—Physical and Electrical Interchangeability and Testing
 - ICS-1-08.....Standard for Industrial Control and Systems General Requirements
 - ICS-2-05.....Standard for Industrial Control and Systems: Controllers, Contractors, and Overload Relays Rated Not More than 2000 Volts AC or 750 Volts DC: Part 8 - Disconnect Devices for Use in Industrial Control Equipment
 - ICS-6-11.....Standard for Industrial Controls and Systems Enclosures
- D. National Fire Protection Association (NFPA):
 - 70-14.....National Electrical Code (NEC)
- E. Underwriters Laboratories, Inc. (UL):
 - 20.....Standard for General-Use Snap Switches
 - 773-95.....Standard for Plug-In Locking Type Photocontrols for Use with Area Lighting
 - 773A-06.....Nonindustrial Photoelectric Switches for Lighting Control

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98-04.....	Enclosed and Dead-Front Switches
916-07.....	Standard for Energy Management Equipment Systems
917-06.....	Clock Operated Switches
924-06.....	Emergency Lighting and Power Equipment (for use when controlling emergency circuits).

PART 2 - PRODUCTS

2.1 INDOOR OCCUPANCY SENSORS

- A. Wall- or ceiling-mounting, solid-state units with a power supply and relay unit, suitable for the environmental conditions in which installed.
1. Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied; with a 1 to 15 minute adjustable time delay for turning lights off.
2. Sensor Output: Contacts rated to operate the connected relay. Sensor shall be powered from the relay unit.
3. Relay Unit: Dry contacts rated for 20A ballast load at 120V and 277V, for 13A tungsten at 120V, and for 1 hp at 120V.
4. Mounting:
 - a. Sensor: Suitable for mounting in any position on a standard outlet box.
 - b. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
5. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.
6. Bypass Switch: Override the on function in case of sensor failure.
7. Manual/automatic selector switch.
8. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc [21.5 to 2152 lx]; keep lighting off when selected lighting level is present.
9. Faceplate for Wall-Switch Replacement Type: Refer to wall plate material and color requirements for toggle switches, as specified in Section 26 27 26, WIRING DEVICES.

2.2 INDOOR VACANCY SENSOR SWITCH

- A. Wall mounting, solid-state units with integral sensor and switch.
1. Operation: Manually turn lights on with switch and sensor detects vacancy to turn lights off.

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2. Switch Rating: 120/277 volt, 1200 watts at 277 volt, 800 watts at 120 volt unit.
3. Mounting:
 - a. Sensor: Suitable for mounting in a standard switch box.
 - b. Time-Delay and Sensitivity Adjustments: Integral with switch and accessible for reprogramming without removing switch.
4. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.
5. Switch: Manual operation to turn lights on and override lights off.
6. Faceplate: Refer to wall plate material and color requirements for toggle switches, as specified in Section 26 27 26, WIRING DEVICES.

2.3 FOLLOW-UP VERIFICATION

- A. Upon completion of acceptance checks and tests, Contractor shall show by demonstration in service that the lighting control devices are in good operating condition and properly performing the intended function in the presence of COR.

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SECTION 26 24 16
PANELBOARDS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, and connection of panelboards.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS:
Requirements that apply to all sections of Division 26.
- B. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES:
Low-voltage conductors.
- C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS:
Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
- D. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS:

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES), in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. Submit the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
1. Shop Drawings:
 - a. Submit sufficient information to demonstrate compliance with drawings and specifications.
 - b. Include electrical ratings, dimensions, mounting details, materials, required clearances, terminations, weight, circuit breakers, wiring and connection diagrams, accessories, and nameplate data.
 2. Manuals:
 - a. Submit, simultaneously with the shop drawings, complete maintenance and operating manuals including technical data sheets, wiring diagrams, and information for ordering circuit breakers and replacement parts.
- 1) Include schematic diagrams, with all terminals identified, matching terminal identification in the panelboards.

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2) Include information for testing, repair, troubleshooting,
assembly, and disassembly.

b. If changes have been made to the maintenance and operating
manuals originally submitted, submit updated maintenance and
operating manuals two weeks prior to the final inspection.

1.5 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions,
supplements, and errata) form a part of this specification to the
extent referenced. Publications are referenced in the text by
designation only.
- B. International Code Council (ICC):
IBC-15.....International Building Code
- C. National Electrical Manufacturers Association (NEMA):
PB 1-11.....Panelboards
250-14.....Enclosures for Electrical Equipment (1,000V
Maximum)
- D. National Fire Protection Association (NFPA):
70-14.....National Electrical Code (NEC)
70E-15.....Standard for Electrical Safety in the Workplace
- E. Underwriters Laboratories, Inc. (UL):
50-13.....Enclosures for Electrical Equipment
67-2009.....Panelboards
489-13.....Molded Case Circuit Breakers and Circuit
Breaker Enclosures

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Panelboards shall be in accordance with NEC, NEMA, UL, as specified,
and as shown on the drawings.
- B. Panelboards shall have main breaker or main lugs, bus size, voltage,
phases, number of circuit breaker mounting spaces, top or bottom feed,
flush or surface mounting, branch circuit breakers, and accessories as
shown on the drawings.
- C. Panelboards shall be completely factory-assembled with molded case
circuit breakers and integral accessories as shown on the drawings or
specified herein.

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- D. Non-reduced size copper bus bars, rigidly supported on molded insulators, and fabricated for bolt-on type circuit breakers.
- E. Bus bar connections to the branch circuit breakers shall be the "distributed phase" or "phase sequence" type.
- F. Mechanical lugs furnished with panelboards shall be cast, stamped, or machined metal alloys listed for use with the conductors to which they will be connected.
- G. Neutral bus shall be 100% rated, mounted on insulated supports.

2.2 MOLDED CASE CIRCUIT BREAKERS

- A. Circuit breakers shall be per UL, NEC, as shown on the drawings, and as specified.
- B. Circuit breakers shall be bolt-on type.
- C. Circuit breakers shall have minimum interrupting rating as required to withstand the available fault current, but not less than:
 - 1. 120/208 V Panelboard: 10,000 A symmetrical.
 - 2. 120/240 V Panelboard: 10,000 A symmetrical.
 - 3. 277/480 V Panelboard: 14,000 A symmetrical.
- D. Circuit breakers shall have automatic, trip free, non-adjustable, inverse time, and instantaneous magnetic trips for less than 400 A frame. Circuit breakers with 400 A frames and above shall have magnetic trip, adjustable from 5x to 10x. Breaker magnetic trip setting shall be set to maximum, unless otherwise noted.
- E. Circuit breaker features shall be as follows:
 - 1. A rugged, integral housing of molded insulating material.
 - 2. Silver alloy contacts.
 - 3. Arc quenchers and phase barriers for each pole.
 - 4. Quick-make, quick-break, operating mechanisms.
 - 5. A trip element for each pole, thermal magnetic type with long time delay and instantaneous characteristics, a common trip bar for all poles and a single operator.
 - 6. Electrically and mechanically trip free.
 - 7. An operating handle which indicates closed, tripped, and open positions.
 - 8. An overload on one pole of a multi-pole breaker shall automatically cause all the poles of the breaker to open.

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9. Ground fault current interrupting breakers, shunt trip breakers, lighting control breakers (including accessories to switch line currents), or other accessory devices or functions shall be provided where shown on the drawings.
10. For circuit breakers being added to existing panelboards, coordinate the breaker type with existing panelboards. Modify the panel directory accordingly.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall be in accordance with the manufacturer's instructions, the NEC, as shown on the drawings, and as specified.
- B. Locate panelboards so that the present and future conduits can be conveniently connected.
- C. //In seismic areas, panelboards shall be adequately anchored and braced per details on structural contract drawings to withstand the seismic forces at the location where installed.//
- D. Install a printed schedule of circuits in each panelboard after approval by the COR. Schedules shall reflect final load descriptions, room numbers, and room names connected to each circuit breaker. Schedules shall be printed on the panelboard directory cards and be installed in the appropriate panelboards
- E. Mount panelboards such that the maximum height of the top circuit breaker above the finished floor shall not exceed 1980 mm (78 inches).
- F. Provide blank cover for each unused circuit breaker mounting space.
- G. Rust and scale shall be removed from the inside of existing enclosures where new interior components are to be installed. Paint inside of enclosures with rust-preventive paint before the new interior components are installed. Provide new trim. Trim shall fit tight to the enclosure.
- H. Panelboard enclosures shall not be used for conductors feeding through, spliced, or tapping off to other enclosures or devices.

3.2 ACCEPTANCE CHECKS AND TESTS

- A. Perform in accordance with the manufacturer's recommendations. In addition, include the following:
 1. Visual Inspection and Tests:

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- a. Compare equipment nameplate data with specifications and approved shop drawings.
- b. Inspect physical, electrical, and mechanical condition.
- c. Verify appropriate anchorage and required area clearances.
- d. Verify that circuit breaker sizes and types correspond to approved shop drawings.
- e. To verify tightness of accessible bolted electrical connections, use the calibrated torque-wrench method or perform thermographic survey after energization.
- f. Vacuum-clean enclosure interior. Clean enclosure exterior.

3.3 FOLLOW-UP VERIFICATION

- A. Upon completion of acceptance checks, settings, and tests, the Contractor shall demonstrate that the panelboards are in good operating condition and properly performing the intended function.

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SECTION 26 24 19
MOTOR CONTROL CENTERS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, connection, and testing of the motor control centers.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS:
Requirements that apply to all sections of Division 26.
- B. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES:
Low-voltage conductors.
- C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS:
Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
- D. Section 26 29 11, MOTOR CONTROLLERS: Control and protection of motors.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES), in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. Submit the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS:
 - 1. Shop Drawings:
 - a. Submit sufficient information to demonstrate compliance with drawings and specifications.
 - b. Prior to fabrication of motor control centers, submit the following data for approval:
 - 1) Single line diagram showing each bus, instrument and control power transformer, relay, motor starter, circuit breaker, fuse, motor circuit protector, overload, and other components.
 - 2) Control wiring diagram for each motor starter.
 - 3) Complete electrical ratings for all components.
 - 4) Interrupting ratings.
 - 5) Safety features.
 - 6) Accessories and nameplate data.
 - 7) Dimensioned exterior views of the motor control centers.
 - 8) Dimensioned section views of the motor control centers.

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9) Floor plan of the motor control centers.

10) Approximate design weights.

2. Manuals:

a. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals, including technical data sheets, wiring diagrams, and information for ordering replacement parts.

1) Schematic control diagrams, with all terminals identified, matching terminal identification in the motor control centers.

2) Include information for testing, repair, troubleshooting, assembly, disassembly, and factory recommended periodic maintenance procedures and their frequency.

3) Provide a replacement and spare parts list. Include a list of tools, and instruments for testing and maintenance purposes.

b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.

3. Test Reports:

a. Two weeks prior to the final inspection, submit certified field test reports and data sheets to the Contracting Officers Representative (COR).

4. Certifications: Two weeks prior to final inspection, submit the following.

a. Certification by the manufacturer that the motor control centers conform to the requirements of the drawings and specifications.

b. Certification by the Contractor that the motor control centers have been properly installed, adjusted, and tested.

1.5 APPLICABLE PUBLICATIONS

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

B. International Code Council (ICC):

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IBC-15.....International Building Code

C. National Electrical Manufacturers Association (NEMA):

ICS 1-15.....Industrial Control and Systems: General
Requirements

ICS 2-05.....Industrial Control and Systems: Controllers,
Contactors and Overhead Relays Rated 600 volts

ICS 6-06.....Industrial Control and Systems: Enclosures

FU 1-12.....Low-Voltage Cartridge Fuses

250-14.....Enclosures for Electrical Equipment (1000 Volts
Maximum)

D. National Fire Protection Association (NFPA):

70-14.....National Electrical Code (NEC)

E. Underwriters Laboratories, Inc. (UL):

845-07.....Motor Control Centers

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Motor control centers shall comply with NFPA, NEMA, UL, and as shown on drawings.
- B. Motor control centers shall be complete, free-standing, floor-mounted, dead-front, and metal-enclosed.
- C. Ratings shall be not less than shown on drawings. Interrupting ratings shall be not less than the maximum short circuit currents available at the motor control center location, as shown on drawings Enclosure shall be NEMA-type rated 1, 3R, or 12 as indicated on drawings or as required per the installed environment.
- D. Motor control centers shall conform to the arrangements and details of drawings and to the spaces designated for installation.
- E. Wiring: Motor control centers shall be NEMA Standard, Class 1, Type B.
- F. Finish:
 - 1. All metal surfaces shall be thoroughly cleaned, phosphatized and factory primed prior to applying baked enamel or lacquer finish.
 - 2. Provide a light gray finish for indoor motor control centers.
 - a. Finish shall be light gray.
 - b. The underside of the motor control centers shall be treated with corrosion resistant compounds, epoxy resin, or rubberized sealing compound.

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G. All steel parts shall be factory-phosphatized, painted with primer, and baked enamel or lacquer finishes, except for ground connections. I.

Vertical Sections:

1. Approximately 2-1/4 M (90 inches) high.
2. Shall be designed to permit connection of future additional vertical sections, and installation of future motor controller units in available space in each vertical section.
3. Spaces within the vertical sections shall be suitable and adequately sized for motor controller units and accessories as indicated on drawings.
4. End panels shall be removable to facilitate future additions.
5. All vertical section parts shall be accessible from the front for maintenance rearrangement.
6. Screws in the removable panels shall remain in the panels when the panels are removed. Self-aligning, self-retaining nuts, which are parts of the screw assembly, shall remain intact.
7. Each vertical section shall have a minimum 300 mm (12 inches) high horizontal wireway at the top, section and a minimum 150 mm (6 inches) high horizontal wireway at the bottom.
8. Each vertical section shall have minimum 100 mm (4 inches) wide vertical full height wireways. Vertical wireways shall connect with both the top and bottom horizontal wireways.
9. Each vertical section for motor controller units shall be equipped with all necessary hardware and busing for the units to be added or relocated. All unused space shall be covered by hinged doors and equipped to accept future units.

2.2 BUS BARS AND INTERCONNECTIONS

- A. Horizontal and vertical bus ratings shall be as shown on drawings. Horizontal bus bars shall be fully rated for the entire length of the motor control centers.
- B. Bus bars shall be tin-plated copper.
- C. All bolts, nuts, and washers shall be zinc-plated steel, torqued to the values recommended by the manufacturer.
- D. A ground bus shall extend across the entire length of the motor control centers.

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- E. Bus bars and interconnections shall include provisions to extend the motor control center horizontal bus into additional future vertical sections.
- F. Provide shutter mechanism to isolate vertical bus when the motor controller unit is withdrawn.

2.3 MOTOR CONTROLLERS

- A. Product of the same manufacturer as the motor control centers.
- B. Shall conform to the applicable requirements in Section 26 29 11, MOTOR CONTROLLERS.
- C. Plug-in, draw-out type up through NEMA size 4. NEMA size 5 and above require bolted connections.
- D. Doors for each space shall be interlocked to prevent their opening unless disconnect is open. A "defeater" mechanism shall be incorporated for inspection by qualified personnel.

2.4 FEEDER UNITS

- A. Circuit breaker: shall conform to the applicable portions of Section 26 24 16, PANELBOARDS.
- B. Fusible Switches: shall conform to the applicable portions of Section 26 29 21, ENCLOSED SWITCHES AND CIRCUIT BREAKERS.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install motor control centers in accordance with the NEC, as shown on the drawings, and as recommended by the manufacturer.
- B. Anchor motor control centers with rustproof bolts, nuts, and washers not less than 13 mm (1/2 inch) diameter, in accordance with manufacturer's instructions, and as shown on drawings.
- C. Interior Location. Mount motor control centers on concrete slab. Unless otherwise indicated, the slab shall be at least 100 mm (4 inches) thick. The top of the concrete slab shall be approximately 100 mm (4 inches) above finished floor. Edges above floor shall have 15 mm (1/2 inch) chamfer. The slab shall be of adequate size to project at least 100 mm (8 inches) beyond the equipment. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 75 mm (3 inches) above slab surface.

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3.2 ACCEPTANCE CHECKS AND TESTS

A. Perform in accordance with the manufacturer's recommendations. In addition, include the following:

1. Visual Inspection and Tests:

- a. Compare equipment nameplate data with specifications and approved shop drawings.
- b. Inspect physical, electrical, and mechanical condition.
- c. Verify appropriate anchorage and required area clearances.
- d. Verify that circuit breaker, fuse, motor circuit protector, and motor controller sizes and types correspond to approved shop drawings.
- e. Use calibrated torque-wrench method to verify the tightness of accessible bolted electrical connections, or perform a thermographic survey after energization.
- f. Vacuum-clean motor control center enclosure interior. Clean motor control center enclosure exterior.
- g. Inspect insulators for evidence of physical damage or contaminated surfaces.
- h. Exercise all active components.
- i. Verify the correct operation of all indicating devices.
- j. If applicable, inspect control power transformers.

2. Electrical Tests:

- a. Perform insulation-resistance tests on each bus section.
- b. Perform insulation-resistance test on control wiring. Do not perform this test on wiring connected to electronic components.

3.3 FOLLOW-UP VERIFICATION

A. Upon completion of acceptance checks, settings, and tests, the Contractor shall demonstrate that the motor control centers are in good operating condition and properly performing the intended function.

3.4 TRAINING

A. Furnish the services of a competent, factory-trained engineer or technician for a 2-hour period to instruct VA personnel in operation and maintenance of the equipment, including review of the operation and maintenance manual, on a date requested by COR.

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SECTION 26 25 11
BUSWAYS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, connection, and testing of busways for use in electrical systems rated 600 V and below.

1.2 RELATED WORK

- A. Section 07 84 00, FIRESTOPPING: Sealing around busway penetrations to maintain the integrity of fire-resistant rated construction.
- B. Section 07 92 00, JOINT SEALANTS: Sealing around busway penetrations through building envelope to prevent moisture migration into building.
- C. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.
- D. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path to ground for possible ground fault currents.
- E. Section 26 24 16, PANELBOARDS: Circuit breakers for use in plug-in busway.
- F. Section 26 29 21, ENCLOSED SWITCHES AND CIRCUIT BREAKERS: Switches and fuses for use in plug-in busway.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES), in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. Submit the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
 - 1. Shop Drawings:
 - a. Submit sufficient information to demonstrate compliance with drawings and specifications.
 - b. Submit the following data for approval:
 - 1) Electrical ratings, dimensions, mounting details and position, mounting method, vertical supports, materials, fire stops, and weatherproofing.
 - 2) Detailed coordinated connections to equipment terminations such as switchgear, switchboards, and transformers.

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3) Coordination Drawings: Submit floor plans and sections, drawn to scale. Include bus assembly layouts and relationships between components and adjacent structural, mechanical, and electrical elements. Indicate vertical and horizontal enclosed busway runs, offsets, transitions, and clearances for access above and to the side of enclosed busways. Indicate vertical elevation of busway above the floor or bottom of structure. Indicate support locations, type of support, and weight on each support.

2. Manuals:

a. Submit complete maintenance and operating manuals including technical data sheets, and information for ordering replacement parts.

1) Include information for testing, repair, troubleshooting, assembly, and disassembly.

b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.

3. Certifications: Two weeks prior to final inspection, submit the following.

a. Certification by the manufacturer that the busway conforms to the requirements of the drawings and specifications.

b. Certification by the Contractor that the busway has been properly installed, adjusted, and tested.

1.5 APPLICABLE PUBLICATIONS

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

B. International Code Council (ICC):

IBC-12.....International Building Code

C. National Electrical Manufacturers Association (NEMA):

BU 1-02.....Busways

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BU 1.1-10.....General Instructions for Handling,
Installation, Operation and Maintenance of
Busway Rated 600 Volts or Less
BU 1.2-08.....Application Information for Busway Rated 600
Volts or Less

D. National Fire Protection Association (NFPA):
70-14.....National Electrical Code (NEC)
E. Underwriters Laboratories Inc. (UL):
857-09.....Busways

PART 2 - PRODUCTS

2.1 MATERIAL

- A. Busway shall be in accordance with NEMA and UL.
- B. Busway shall be rated as shown on the drawings.
- C. Busway shall have the following features:
 - 1. For indoor locations; plug-in type, totally enclosed and moisture resistant.
 - 2. Short circuit current rating shall not be less than 42,000 A, or as required to withstand the available fault current shown on the drawings, whichever is higher.
 - 3. 3-phase, 4-wire, with full 200% neutral, except where 3-phase, 3-wire is shown on the drawings.
 - 4. Internal 50%-rated ground bus bar. Busway housing is not allowed to serve as the equipment grounding conductor.
 - 5. All bus bars, phase, neutral, and ground, for each busway shall be within a single housing.
- 6. Bus Bars:
 - a. Shall be full round edge rectangular copper of sufficient cross-section to provide full current rating without exceeding a temperature rise of 55° C above a 40° C ambient.
 - b. Interconnection joints shall be tin or silver plated, with steel bolts, nuts, and Belleville washers.
 - c. Shall be completely insulated with flame-retardant, track-resistant, self-extinguishing insulation.
- 7. Housings:
 - a. Shall be steel or aluminum, with continuous mounting rails.

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- b. Shall be thoroughly cleaned and painted at the factory with primer and the manufacturer's standard finish.
 - c. Shall have rustproof metal hardware.
 - d. For busways that pass through fire-resistant rated construction, incorporate listed fire stops within the busway housings and external flanges.
 - e. Install expansion fittings in the busway runs in compliance with the manufacturer's standard recommendations.
 - f. The temperature rise at any point on the housing shall not exceed 30° C above an ambient temperature of 40° C.
- 8. Busway shall not be reduced in size at any point.
 - 9. Provide manufacturer's fittings and accessories, including but not limited to elbows, tees, tap boxes end boxes, expansion fittings, offsets, adapters, hangers, and mounting hardware.
- D. Dimensions and Configuration:
- 1. Configure within the space designated for busway installation.
 - 2. Coordinate busway routing with equipment installation by other trades to avoid conflicts.
 - 3. Make final field measurements and check them with the busway coordination drawings prior to authorization of fabrication of the busways.
- D. Fusible-type plug-in units shall have a quick-make/quick-break disconnect switch and positive pressure fuse clips. Provide fuses as specified in Section 26 29 21, ENCLOSED SWITCHES AND CIRCUIT BREAKERS, and as shown on the drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install busways as required by the NEC and the manufacturer's requirements.
- B. Support busways as required by the NEC and as required by manufacturer's shop drawings.
- C. Coordinate all of the busway terminations to equipment to ensure proper phasing.
- D. Tighten bolted connections with a torque wrench to values as required by the manufacturer.

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- E. Install expansion fittings at locations where busways cross building expansion joints. Install at other locations so distance between expansion fittings does not exceed manufacturer's recommended distance between fittings.
- F. Install fire-stop assemblies per Section 07 84 00, FIRESTOPPING where busways penetrate fire-resistant construction.

3.2 ACCEPTANCE CHECKS AND TESTS

- A. Perform manufacturer's required field tests in accordance with the manufacturer's recommendations. In addition, include the following:

- 1. Visual Inspection and Tests:

- a. Compare equipment nameplate data with specifications and approved shop drawings.
 - b. Inspect physical, electrical, and mechanical condition.
 - c. Verify appropriate anchorage, required area clearances, and correct alignment.
 - d. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey after energization.
 - e. Verify appropriate equipment grounding.
 - f. Examine outdoor busways for removal of weep-hole plugs, if applicable, and the correct installation of joint shield.

- 2. Electrical Tests:

- a. After installation, test busway phase-to-phase and phase-to-ground resistance with an insulation resistance tester.
Resulting values shall not be less than one megohm.

3.3 FOLLOW-UP VERIFICATION

- A. Upon completion of acceptance checks and tests, the Contractor shall show by demonstration in service that the busway is in good operating condition and properly performing the intended function.
- B. After the busways have been energized for not less than 30 days, repeat the torque wrench tightening of all bolt connections.

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SECTION 26 27 26
WIRING DEVICES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, connection, and testing of wiring devices.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements that are common to more than one section of Division 26.
- B. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduit and boxes.
- C. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Cables and wiring.
- D. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path to ground for possible ground fault currents.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES), in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. Submit the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
 - 1. Shop Drawings:
 - a. Submit sufficient information to demonstrate compliance with drawings and specifications.
 - b. Include electrical ratings, dimensions, mounting details, construction materials, grade, and termination information.
 - 2. Manuals:
 - a. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals, including technical data sheets and information for ordering replacement parts.
 - b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.

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3. Certifications: Two weeks prior to final inspection, submit the following.

- a. Certification by the manufacturer that the wiring devices conform to the requirements of the drawings and specifications.
- b. Certification by the Contractor that the wiring devices have been properly installed and adjusted.

1.5 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by basic designation only.
- B. National Fire Protection Association (NFPA):
70-14.....National Electrical Code (NEC)
99-15.....Health Care Facilities
- C. National Electrical Manufacturers Association (NEMA):
WD 1-15.....General Color Requirements for Wiring Devices
WD 6-16Wiring Devices - Dimensional Specifications
- D. Underwriter's Laboratories, Inc. (UL):
5-16.....Surface Metal Raceways and Fittings
20-10.....General-Use Snap Switches
231-08.....Power Outlets
467-13.....Grounding and Bonding Equipment
498-12.....Attachment Plugs and Receptacles
943-16.....Ground-Fault Circuit-Interrupters
1449-14.....Surge Protective Devices
1472-96.....Solid State Dimming Controls

PART 2 - PRODUCTS

2.1 RECEPTACLES

- A. General: All receptacles shall comply with NEMA, NFPA, UL, and as shown on the drawings.
 1. Mounting straps shall be plated steel, with break-off plaster ears and shall include a self-grounding feature. Terminal screws shall be brass, brass plated or a copper alloy metal.

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2. Receptacles shall have provisions for back wiring with separate metal clamp type terminals (four minimum) and side wiring from four captively held binding screws.
- B. Duplex Receptacles: Hospital-grade, single phase, 20 ampere, 120 volts, 2-pole, 3-wire, NEMA 5-20R, with break-off feature for two-circuit operation.
 1. Bodies shall be Gray in color.
 2. Ground Fault Interrupter Duplex Receptacles: Shall be an integral unit, hospital-grade, suitable for mounting in a standard outlet box, with end-of-life indication and provisions to isolate the face due to improper wiring.
 - a. Ground fault interrupter shall be consist of a differential current transformer, solid state sensing circuitry and a circuit interrupter switch. Device shall have nominal sensitivity to ground leakage current of 4-6 milliamperes and shall function to interrupt the current supply for any value of ground leakage current above five milliamperes (+ or - 1 milliampere) on the load side of the device. Device shall have a minimum nominal tripping time of 0.025 second.
 - b. Ground Fault Interrupter Duplex Receptacles (not hospital-grade) shall be the same as ground fault interrupter hospital-grade receptacles except for the hospital-grade listing.
3. Safety Type Duplex Receptacles:
 - a. Bodies shall be gray in color.
 - 1) Shall permit current to flow only while a standard plug is in the proper position in the receptacle.
 - 2) Screws exposed while the wall plates are in place shall be the tamperproof type.
4. Duplex Receptacles (not hospital grade): Shall be the same as hospital grade duplex receptacles except for the hospital grade listing and as follows.
 - a. Bodies shall be brown nylon.
- C. Receptacles; 20, 30, and 50 ampere, 250 Volts: Shall be complete with appropriate cord grip plug.
- D. Weatherproof Receptacles: Shall consist of a duplex receptacle, mounted in box with a gasketed, weatherproof, cast metal cover plate and cap

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over each receptacle opening. The cap shall be permanently attached to the cover plate by a spring-hinged flap. The weatherproof integrity shall not be affected when heavy duty specification or hospital grade attachment plug caps are inserted. Cover plates on outlet boxes mounted flush in the wall shall be gasketed to the wall in a watertight manner.

2.2 TOGGLE SWITCHES

- A. Toggle switches shall be totally enclosed tumbler type with nylon bodies. Handles shall be ivory in color unless otherwise specified or shown on the drawings.
 - 1. Shall be single unit toggle, butt contact, quiet AC type, heavy-duty general-purpose use with an integral self-grounding mounting strap with break-off plasters ears and provisions for back wiring with separate metal wiring clamps and side wiring with captively held binding screws.
 - 2. Switches shall be rated 20 amperes at 120-277 Volts AC.

2.3 WALL PLATES

- A. Wall plates for switches and receptacles shall be type 302 stainless steel. Oversize plates are not acceptable.
- B. Color shall be ivory unless otherwise specified.
- C. For receptacles or switches mounted adjacent to each other, wall plates shall be common for each group of receptacles or switches.
- D. In areas requiring tamperproof wiring devices, wall plates shall be type 302 stainless steel, and shall have tamperproof screws and beveled edges.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall be in accordance with the NEC and as shown as on the drawings.
- B. Install wiring devices after wall construction and painting is complete.
- C. The ground terminal of each wiring device shall be bonded to the outlet box with an approved green bonding jumper, and also connected to the branch circuit equipment grounding conductor.
- D. Outlet boxes for toggle switches shall be mounted on the strike side of doors.
- E. Provide barriers in multigang outlet boxes to comply with the NEC.
- F. Coordinate the electrical work with the work of other trades to ensure

that wiring device flush outlets are positioned with box openings aligned with the face of the surrounding finish material. Exact field locations of floors, walls, partitions, doors, windows, and equipment may vary from locations shown on the drawings. Prior to locating sleeves, boxes and chases for roughing-in of conduit and equipment, the Contractor shall coordinate exact field location of the above items with other trades.

- G. Install wall switches 1.2 M (48 inches) above floor, with the toggle OFF position down.
- H. Install receptacles 450 mm (18 inches) above floor, and 152 mm (6 inches) above counter backsplash or workbenches. Install specific-use receptacles at heights shown on the drawings.
- I. Install vertically mounted receptacles with the ground pin up. Install horizontally mounted receptacles with the ground pin to the right.
- J. When required or recommended by the manufacturer, use a torque screwdriver. Tighten unused terminal screws.
- K. Label device plates with a permanent adhesive label listing panel and circuit feeding the wiring device.

3.2 ACCEPTANCE CHECKS AND TESTS

- A. Perform manufacturer's required field checks in accordance with the manufacturer's recommendations. In addition, include the following:
 - 1. Visual Inspection and Tests:
 - a. Inspect physical and electrical condition.
 - b. Vacuum-clean surface metal raceway interior. Clean metal raceway exterior.
 - c. Test wiring devices for damaged conductors, high circuit resistance, poor connections, inadequate fault current path, defective devices, or similar problems using a portable receptacle tester. Correct circuit conditions, remove malfunctioning units and replace with new, and retest as specified above.
 - d. Test GFCI receptacles.
 - 2. Healthcare Occupancy Tests:
 - a. Test hospital grade receptacles for retention force per NFPA 99.

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SECTION 26 29 11
MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, connection, and testing of motor controllers, including all low- and medium-voltage motor controllers and manual motor controllers, indicated as motor controllers in this section, and low-voltage variable speed motor controllers.
- B. Motor controllers, whether furnished with the equipment specified in other sections or otherwise (with the exception of elevator motor controllers specified in Division 14 and fire pump controllers specified in Division 21), shall meet this specification and all related specifications.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS:
Requirements that apply to all sections of Division 26.
- B. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES:
Low-voltage conductors.
- C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS:
Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
- D. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits.
- E. Section 26 24 19, MOTOR CONTROL CENTERS: For multiple motor control assemblies which include motor controllers.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES), in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. Submit the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
 - 1. Shop Drawings:
 - a. Submit sufficient information to demonstrate compliance with drawings and specifications.
 - b. Include electrical ratings, dimensions, weights, mounting details, materials, overcurrent protection devices, overload

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relays, sizes of enclosures, wiring diagrams, starting characteristics, interlocking, and accessories.

2. Manuals:

- a. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals, including technical data sheets, wiring diagrams, and information for ordering replacement parts.
 - 1) Wiring diagrams shall have their terminals identified to facilitate installation, maintenance, and operation.
 - 2) Wiring diagrams shall indicate internal wiring for each item of equipment and interconnections between the items of equipment.
 - 3) Elementary schematic diagrams shall be provided for clarity of operation.
 - 4) Include the catalog numbers for the correct sizes of overload relays for the motor controllers.
- b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.

3. Certifications: Two weeks prior to final inspection, submit the following.

- a. Certification by the manufacturer that the motor controllers conform to the requirements of the drawings and specifications.
- b. Certification by the Contractor that the motor controllers have been properly installed, adjusted, and tested.

1.5 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by basic designation only.
- B. Institute of Electrical and Electronic Engineers (IEEE):
 - 519-14.....Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems

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C37.90.1-12.....Standard Surge Withstand Capability (SWC) Tests
for Relays and Relay Systems Associated with
Electric Power Apparatus

C. International Code Council (ICC):

IBC-15.....International Building Code

D. National Electrical Manufacturers Association (NEMA):

ICS 1-15.....Industrial Control and Systems: General
Requirements

ICS 1.1-15.....Safety Guidelines for the Application,
Installation and Maintenance of Solid State
Control

ICS 2-05.....Industrial Control and Systems Controllers,
Contactors, and Overload Relays Rated 600 Volts

ICS 4-15.....Industrial Control and Systems: Terminal Blocks

ICS 6-06.....Industrial Control and Systems: Enclosures

ICS 7-14.....Industrial Control and Systems: Adjustable-
Speed Drives

ICS 7.1-14.....Safety Standards for Construction and Guide for
Selection, Installation, and Operation of
Adjustable-Speed Drive Systems

MG 1-2014 Part 31.....Inverter Fed Polyphase Motor Standards

E. National Fire Protection Association (NFPA):

70-14.....National Electrical Code (NEC)

F. Underwriters Laboratories Inc. (UL):

508A-13.....Industrial Control Panels

508C-12.....Power Conversion Equipment

UL 1449-14.....Surge Protective Devices

PART 2 - PRODUCTS

2.1 MOTOR CONTROLLERS

- A. Motor controllers shall comply with IEEE, NEMA, NFPA, UL, and as shown on the drawings.
- B. Motor controllers shall be separately enclosed, unless part of another assembly. For installation in motor control centers, provide plug-in, draw-out type motor controllers up through NEMA size 4. NEMA size 5 and above require bolted connections.

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C. Motor controllers shall be combination type, with magnetic controller per Paragraph 2.3 below and with circuit breaker disconnecting means, with external operating handle with lock-open padlocking positions and ON-OFF position indicator.

1. Circuit Breakers:

- a. Bolt-on thermal-magnetic type with a minimum interrupting rating as indicated on the drawings.
- b. Equipped with automatic, trip free, non-adjustable, inverse-time, and instantaneous magnetic trips for less than 400A. The magnetic trip shall be adjustable from 5x to 10x for breakers 400A and greater.
- c. Additional features shall be as follows:
 - 1) A rugged, integral housing of molded insulating material.
 - 2) Silver alloy contacts.
 - 3) Arc quenchers and phase barriers for each pole.
 - 4) Quick-make, quick-break, operating mechanisms.
 - 5) A trip element for each pole, a common trip bar for all poles, and one operator for all poles.

2. Fused Switches:

- a. Quick-make, quick-break type.
- b. Minimum duty rating shall be NEMA classification General Duty (GD) for 240 Volts and NEMA classification Heavy Duty (HD) for 480 Volts.
- c. Horsepower rated, and shall have the following features:
 - 1) Copper blades, visible in the OFF position.
 - 2) An arc chute for each pole.

D. Fuse holders for the sizes and types of fuses specified or as shown on the drawings.

E. Enclosures:

- 1. Enclosures shall be NEMA-type rated 1, 3R, or 12 as indicated on the drawings or as required per the installed environment.
- 2. Enclosure doors shall be interlocked to prevent opening unless the disconnecting means is open. A "defeater" mechanism shall allow for inspection by qualified personnel with the disconnect means closed. Provide padlocking provisions.

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3. All metal surfaces shall be thoroughly cleaned, phosphatized, and factory primed prior to applying light gray baked enamel finish.
- F. Motor control circuits:
1. Shall operate at not more than 120 Volts.
 2. Shall be grounded, except where the equipment manufacturer recommends that the control circuits be isolated.
 3. For each motor operating over 120 Volts, incorporate a separate, heavy duty, control transformer within each motor controller enclosure.
 4. Incorporate primary and secondary overcurrent protection for the control power transformers.
- G. Overload relays:
1. Thermal type. Devices shall be NEMA type.
 2. One for each pole.
 3. External overload relay reset pushbutton on the door of each motor controller enclosure.
 4. Overload relays shall be matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 5. Thermal overload relays shall be tamperproof, not affected by vibration, manual reset, sensitive to single-phasing, and shall have selectable trip classes of 10, 20 and 30.
- H. Hand-Off-Automatic (H-O-A) switch is required unless specifically stated on the drawings as not required for a particular controller. H-O-A switch shall be operable without opening enclosure door. H-O-A switch is not required for manual motor controllers.
- I. Incorporate into each control circuit a 120 Volt, electronic time-delay relay (ON delay), minimum adjustable range from 0.3 to 10 minutes, with transient protection. Time-delay relay is not required where H-O-A switch is not required.
- J. Unless noted otherwise, equip each motor controller with not less than two normally open (N.O.) and two normally closed (N.C.) auxiliary contacts.
- K. Provide green (RUN) and red (STOP) pilot lights.
- L. Motor controllers incorporated within equipment assemblies shall also be designed for the specific requirements of the assemblies.

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M. Additional requirements for specific motor controllers, as indicated in other specification sections, shall also apply.

2.2 LOW-VOLTAGE VARIABLE SPEED MOTOR CONTROLLERS (VSMC)

- A. VSMC shall be in accordance with applicable portions of 2.1 above.
- B. VSMC shall be electronic, with adjustable frequency and voltage, three phase output, capable of driving standard NEMA B three-phase induction motors at full rated speed. The control technique shall be pulse width modulation (PWM), where the VSMC utilizes a full wave bridge design incorporating diode rectifier circuitry. Silicon controlled rectifiers or other control techniques are not acceptable.
- C. VSMC shall be suitable for variable torque loads, and shall be capable of providing sufficient torque to allow the motor to break away from rest upon first application of power.
- D. VSMC shall be capable of operating within voltage parameters of plus 10 to minus 15 percent of line voltage, and be suitably rated for the full load amps of the maximum watts (HP) within its class.
- E. Minimum efficiency shall be 95 percent at 100 percent speed and 85 percent at 50 percent speed.
- F. The displacement power factor of the VSMC shall not be less than 95 percent under any speed or load condition.
- G. VSMC current and voltage harmonic distortion shall not exceed the values allowed by IEEE 519.
- H. Operating and Design Conditions:
 - 1. Temperatures: Maximum 105°F Minimum -10°F
 - 2. Relative Humidity: 95%
 - 3. VSMC Location: Mechanical Room
- I. VSMC shall have the following features:
 - 1. Isolated power for control circuits.
 - 2. Manually resettable overload protection for each phase.
 - 3. Adjustable current limiting circuitry to provide soft motor starting. Maximum starting current shall not exceed 200 percent of motor full load current.
 - 4. Independent acceleration and deceleration time adjustment, manually adjustable from 2 to 2000 seconds. Set timers to the equipment manufacturer's recommended time in the above range.

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5. Control input circuitry that will accept 4 to 20 mA current or 0-10 VDC voltage control signals from an external source.
6. Automatic frequency adjustment from 1 Hz to 300 Hz.
7. Circuitry to initiate an orderly shutdown when any of the conditions listed below occur. The VSMC shall not be damaged by any of these electrical disturbances and shall automatically restart when the conditions are corrected. The VSMC shall be able to restart into a rotating motor operating in either the forward or reverse direction and matching that frequency.
 - a. Incorrect phase sequence.
 - b. Single phasing.
 - c. Overvoltage in excess of 10 percent.
 - d. Undervoltage in excess of 15 percent.
 - e. Running overcurrent above 110 percent (VSMC shall not automatically reset for this condition.)
 - f. Instantaneous overcurrent above 150 percent (VSMC shall not automatically reset for this condition).
 - g. Short duration power outages of 12 cycles or less (i.e., distribution line switching, generator testing, and automatic transfer switch operations.)
8. Automatic Reset/Restart: Attempt three restarts after VSMC fault or on return of power after an interruption and before shutting down for manual reset or fault correction, with adjustable delay time between restart attempts.
9. Bidirectional Autospeed Search: Capable of starting VSMC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to VSMC, motor, or load.
- J. VSMC shall include an input circuit breaker which will disconnect all input power, interlocked with the door so that the door cannot be opened with the circuit breaker in the closed position.
- K. VSMC shall include a 5% line reactor and a RFI/EMI filter.
- L. Surge Suppression: Provide three-phase protection against damage from supply voltage surges in accordance with UL 1449.

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- M. VSMC shall include front-accessible operator station, with sealed keypad and digital display, which allows complete programming, operating, monitoring, and diagnostic capabilities.
1. Typical control functions shall include but not be limited to:
 - a. HAND-OFF-AUTOMATIC-RESET, with manual speed control in HAND mode.
 - b. NORMAL-BYPASS.
 - c. NORMAL-TEST, which allows testing and adjusting of the VSMC while in bypass mode.
 2. Typical monitoring functions shall include but not be limited to:
 - a. Output frequency (Hz).
 - b. Motor speed and status (run, stop, fault).
 - c. Output voltage and current.
 3. Typical fault and alarm functions shall include but not be limited to:
 - a. Loss of input signal, under- and over-voltage, inverter overcurrent, motor overload, critical frequency rejection with selectable and adjustable deadbands, instantaneous line-to-line and line-to-ground overcurrent, loss-of-phase, reverse-phase, and short circuit.
 - b. System protection indicators indicating that the system has shutdown and will not automatically restart.
- N. VSMC shall include two N.O. and two N.C. dry contacts rated 120 Volts, 10 amperes, 60 Hz.
- O. Hardware, software, network interfaces, gateways, and programming to control and monitor VSMC by control systems specified in specification sections, including but not limited to Divisions 22 and 23.
- P. Network communications ports: As required for connectivity to control systems specified in other specification sections, including but not limited to Divisions 22 and 23.
- Q. Communications protocols: As required for communications with control systems specified in other specification sections, including but not limited to Divisions 22 and 23.
- R. Bypass controller: Provide contactor-style bypass, arranged to bypass the inverter.

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1. Inverter Output Contactor and Bypass Contactor: Load-break NEMA-rated contactor.
2. Motor overload relays.
3. HAND-OFF-AUTOMATIC bypass control.
- S. Bypass operation: Transfers motor between inverter output and bypass circuit, manually, automatically, or both. VSMC shall be capable of stable operation (starting, stopping, and running), and control by fire alarm and detection systems, with motor completely disconnected from the inverter output. Transfer between inverter and bypass contactor and retransfer shall only be allowed with the motor at zero speed.
- T. Inverter Isolating Switch: Provide non-load-break switch arranged to isolate inverter and permit safe troubleshooting and testing of the inverter, both energized and de-energized, while motor is operating in bypass mode. Include padlockable, door-mounted handle mechanism.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install motor controllers in accordance with the NEC, as shown on the drawings, and as recommended by the manufacturer.
- B. Install manual motor controllers in flush enclosures in finished areas.
- C. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and electronic overload relay pickup and trip ranges.
- D. Program variable speed motor controllers per the manufacturer's instructions and in coordination with other trades so that a complete and functional system is delivered.
- E. Adjust trip settings of circuit breakers and motor circuit protectors with adjustable instantaneous trip elements. Initially adjust at six times the motor nameplate full-load ampere ratings and attempt to start motors several times, allowing for motor cooldown between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficiency motors if required). Where these maximum settings do not allow starting of a motor, notify Contracting Officers Representative (COR) before increasing settings.
- F. Set the taps on reduced-voltage autotransformer controllers at 50 percent of line voltage.

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3.2 ACCEPTANCE CHECKS AND TESTS

- A. Perform manufacturer's required field tests in accordance with the manufacturer's recommendations. In addition, include the following:
 - 1. Visual Inspection and Tests:
 - a. Compare equipment nameplate data with specifications and approved shop drawings.
 - b. Inspect physical, electrical, and mechanical condition.
 - c. Verify appropriate anchorage, required area clearances, and correct alignment.
 - d. Verify that circuit breaker, motor circuit protector, and fuse sizes and types correspond to approved shop drawings.
 - e. Verify overload relay ratings are correct.
 - f. Vacuum-clean enclosure interior. Clean enclosure exterior.
 - g. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data.
 - h. Test all control and safety features of the motor controllers.
 - i. For low-voltage variable speed motor controllers, final programming and connections shall be by a factory-trained technician. Set all programmable functions of the variable speed motor controllers to meet the requirements and conditions of use.

3.3 FOLLOW-UP VERIFICATION

- A. Upon completion of acceptance checks, settings, and tests, the Contractor shall show by demonstration in service that the motor controllers are in good operating condition and properly performing the intended functions.

3.4 SPARE PARTS

- A. Two weeks prior to the final inspection, provide one complete set of spare fuses for each motor controller.

3.5 INSTRUCTION

- A. Furnish the services of a factory-trained technician for two 4-hour training periods for instructing personnel in the maintenance and operation of the motor controllers, on the dates requested by the COR.

---END---

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SECTION 26 29 21
ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, and connection of fused and unfused disconnect switches (indicated as switches in this section), and separately-enclosed circuit breakers for use in electrical systems rated 600 V and below.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS:
Requirements that apply to all sections of Division 26.
- B. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES:
Low-voltage conductors.
- C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS:
Requirements for personnel safety and to provide a low impedance path for possible ground faults.
- D. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits.
- E. Section 26 24 16, PANELBOARDS: Molded-case circuit breakers.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES), in Section

1.4 SUBMITTALS

- A. Submit the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
 - 1. Shop Drawings:
 - a. Submit sufficient information to demonstrate compliance with drawings and specifications.
 - b. Submit the following data for approval:
 - 1) Electrical ratings, dimensions, mounting details, materials, required clearances, terminations, weight, fuses, circuit breakers, wiring and connection diagrams, accessories, and device nameplate data.
 - 2. Manuals:
 - a. Submit complete maintenance and operating manuals including technical data sheets, wiring diagrams, and information for ordering fuses, circuit breakers, and replacement parts.

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- 1) Include schematic diagrams, with all terminals identified, matching terminal identification in the enclosed switches and circuit breakers.
- 2) Include information for testing, repair, troubleshooting, assembly, and disassembly.
- b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
3. Certifications: Two weeks prior to final inspection, submit the following.
 - a. Certification by the manufacturer that the enclosed switches and circuit breakers conform to the requirements of the drawings and specifications.
 - b. Certification by the Contractor that the enclosed switches and circuit breakers have been properly installed, adjusted, and tested.

1.5 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. International Code Council (ICC):
IBC-15.....International Building Code
- C. National Electrical Manufacturers Association (NEMA):
FU 1-12.....Low Voltage Cartridge Fuses
KS 1-06.....Enclosed and Miscellaneous Distribution
Equipment Switches (600 Volts Maximum)
- D. National Fire Protection Association (NFPA):
70-14.....National Electrical Code (NEC)
- E. Underwriters Laboratories, Inc. (UL):
98-16.....Enclosed and Dead-Front Switches
248-11.....Low Voltage Fuses
489-13.....Molded Case Circuit Breakers and Circuit
Breaker Enclosures

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PART 2 - PRODUCTS

2.1 FUSED SWITCHES RATED 600 AMPERES AND LESS

- A. Switches shall be in accordance with NEMA, NEC, UL, as specified, and as shown on the drawings.
- B. Shall be NEMA classified General Duty (GD) for 240 V switches, and NEMA classified Heavy Duty (HD) for 480 V switches.
- C. Shall be horsepower (HP) rated.
- D. Shall have the following features:
 1. Switch mechanism shall be the quick-make, quick-break type.
 2. Copper blades, visible in the open position.
 3. An arc chute for each pole.
 4. External operating handle shall indicate open and closed positions, and have lock-open padlocking provisions.
 5. Mechanical interlock shall permit opening of the door only when the switch is in the open position, defeatable to permit inspection.
 6. Fuse holders for the sizes and types of fuses specified.
 7. Solid neutral for each switch being installed in a circuit which includes a neutral conductor.
 8. Ground lugs for each ground conductor.
 9. Enclosures:
 - a. Shall be the NEMA types shown on the drawings.
 - b. Where the types of switch enclosures are not shown, they shall be the NEMA types most suitable for the ambient environmental conditions.
 - c. Shall be finished with manufacturer's standard gray baked enamel paint over pretreated steel.
 10. Electrically operated switches shall only be installed where shown on the drawings.

2.2 UNFUSED SWITCHES RATED 600 AMPERES AND LESS

- A. Shall be the same as fused switches, but without provisions for fuses.

2.3 MOTOR RATED TOGGLE SWITCHES

- A. Type 1, general purpose for single-phase motors rated up to 1 horsepower.
- B. Quick-make, quick-break toggle switch with external reset button and thermal overload protection matched to nameplate full-load current of actual protected motor.

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2.4 CARTRIDGE FUSES

- A. Shall be in accordance with NEMA FU 1.
- B. Motor Branch Circuits: Class RK1, time delay.
- C. Other Branch Circuits: Class RK1, time delay.
- D. Control Circuits: time delay.

2.6 SEPARATELY-ENCLOSED CIRCUIT BREAKERS

- A. Provide circuit breakers in accordance with the applicable requirements in Section 26 24 16, PANELBOARDS.
- B. Enclosures shall be the NEMA types shown on the drawings. Where the types are not shown, they shall be the NEMA type most suitable for the ambient environmental conditions.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall be in accordance with the manufacturer's instructions, the NEC, as shown on the drawings, and as specified.
- B. Fused switches shall be furnished complete with fuses. Arrange fuses such that rating information is readable without removing the fuses.

3.2 ACCEPTANCE CHECKS AND TESTS

- A. Perform in accordance with the manufacturer's recommendations. In addition, include the following:
 - 1. Visual Inspection and Tests:
 - a. Compare equipment nameplate data with specifications and approved shop drawings.
 - b. Inspect physical, electrical, and mechanical condition.
 - c. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method.
 - d. Vacuum-clean enclosure interior. Clean enclosure exterior.

3.3 SPARE PARTS

- A. Two weeks prior to the final inspection, furnish one complete set of spare fuses for each fused disconnect switch installed on the project. Deliver the spare fuses to Contracting Officers Representative (COR).

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SECTION 26 36 23
AUTOMATIC TRANSFER SWITCHES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, connection, and testing of open-transition automatic transfer switches with bypass isolation, indicated as automatic transfer switches or ATS in this section.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS:
Requirements that apply to all sections of Division 26.
- B. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES:
Low-voltage conductors.
- C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS:
Requirements for personal safety and to provide a low impedance path for possible ground fault currents.
- D. Section 26 05 33, RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS: Conduits.
- E. section in Division 27.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES), in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- B. A factory-authorized representative shall be capable of providing emergency maintenance and repairs at the project site within 4 hours maximum of notification.
- C. Automatic transfer switch, bypass/isolation switch, and annunciation control panels shall be products of the same manufacturer.

1.4 FACTORY TESTS

- A. Automatic transfer switches shall be thoroughly tested at the factory to ensure that there are no electrical or mechanical defects. Tests shall be conducted per UL standards. Factory tests shall be certified, and shall include the following tests:
 - 1. Visual inspection to verify that each ATS is as specified.
 - 2. Mechanical test to verify that ATS sections are free of mechanical hindrances.
 - 3. Insulation resistance test to ensure electrical integrity and continuity of entire system.

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4. Main switch contact resistance test.
5. Electrical tests to verify complete system electrical operation.
- B. Furnish four (4) copies of certified manufacturer's factory test reports to the Contracting Officers Representative (COR) prior to shipment of the ATS to ensure that the ATS has been successfully tested as specified.

1.5 SUBMITTALS

- A. Submit the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1. Shop Drawings:

- a. Submit sufficient information to demonstrate compliance with drawings and specifications.
- b. Include voltage rating, continuous current rating, number of phases, withstand and closing rating, dimensions, weights, mounting details, conduit entry provisions, front view, side view, equipment and device arrangement, elementary and interconnection wiring diagrams, factory relay settings, and accessories.
- c. For automatic transfer switches that are networked together to a common means of annunciation and/or control, submit interconnection diagrams as well as site and building plans, showing connections for normal and emergency sources of power, load, control and annunciation components, and interconnecting communications paths. Equipment locations on the diagrams and plans shall match the site, building, and room designations on the drawings.
- d. Complete nameplate data, including manufacturer's name and catalog number.
- e. A copy of the markings that are to appear on the automatic transfer switches when installed.

2. Manuals:

- a. Submit, simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals, including technical data sheets, wiring diagrams, and information for ordering replacement parts.

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- 1) Schematic signal and control diagrams, with all terminals identified, matching terminal identification in the automatic transfer switches.
 - 2) Include information for testing, repair, troubleshooting, assembly, disassembly, and factory recommended/required periodic maintenance procedures and frequency.
 - 3) Provide a replacement and spare parts list. Include a list of tools and instruments for testing and maintenance purposes.
- b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
- 1) Include complete "As Installed" diagrams that indicate all pieces of equipment and their interconnecting wiring.
 - 2) Include complete diagrams of the internal wiring for each piece of equipment, including "As Installed" revisions of the diagrams.
 - 3) The wiring diagrams shall identify the terminals to facilitate installation, maintenance, operation, and testing.
3. Certifications:
- a. When submitting the shop drawings, submit a certified test report from a recognized independent testing laboratory that a representative sample has passed UL 1008 prototype testing.
 - b. Two weeks prior to final inspection, submit the following.
 - 1) Certification by the manufacturer that the ATS conform to the requirements of the drawings and specifications.
 - 2) Certification by the Contractor that transfer switches have been properly installed, adjusted, and tested.

1.6 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. Institute of Electrical and Electronic Engineers (IEEE):

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- 446-00.....Emergency and Standby Power Systems for
Industrial and Commercial ApplicationsC37.90.1-
02 Surge Withstand Capability (SWC) Tests
for Relays and Relay Systems Associated with
Electric Power Apparatus
- C62.41.1-08.....Guide on the Surges Environment in Low-Voltage
(1000 V and Less) AC Power Circuits
- C62.41.2-02.....Recommended Practice on Characterization of
Surges in Low-Voltage (1000 V and Less) AC
Power Circuits
- C. International Code Council (ICC):
IBC-15.....International Building Code
- D. National Electrical Manufacturers Association (NEMA):
250-14.....Enclosures for Electrical Equipment (1000 Volts
Maximum)
- ICS 6-06.....Enclosures
- ICS 4-15.....Application Guideline for Terminal Blocks
- MG 1-14.....Motors and Generators
- E. National Fire Protection Association (NFPA):
70-14.....National Electrical Code (NEC)
- 99-15.....Health Care Facilities
- 110-16.....Emergency and Standby Power Systems
- F. Underwriters Laboratories, Inc. (UL):
50-15.....Enclosures for Electrical Equipment
- 508-99.....Industrial Control Equipment
- 891-05.....Switchboards
- 1008-14.....Transfer Switch Equipment

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Automatic transfer switches shall comply with UL, NEMA, NEC, ANSI, IEEE, and NFPA, and have the following features:
1. Automatic transfer switches shall be open transition switches, 4-pole, draw-out construction, electrically operated, mechanically held open contact type, without integral overcurrent protection. Automatic transfer switches utilizing automatic or non-automatic

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molded case circuit breakers, insulated case circuit breakers, or power circuit breakers as switching mechanisms are not acceptable.

2. Automatic transfer switches shall be completely factory-assembled and wired such that only external circuit connections are required in the field.
3. Each automatic transfer switch shall be equipped with an integral bypass/isolation switch.
4. Ratings:
 - a. Phases, voltage, continuous current, poles, and withstand and closing ratings shall be as shown on the drawings.
 - b. Transfer switches are to be rated for continuous duty at specified continuous current rating on 60Hz systems.
 - c. Maximum automatic transfer switch rating: 800 A.
5. Markings:
 - a. Markings shall be in accordance with UL 1008.
6. Tests:
 - a. Automatic transfer switches shall be tested in accordance with UL 1008. The contacts of the transfer switch shall not weld during the performance of withstand and closing tests when used with the upstream overcurrent device and available fault current specified.
7. Surge Withstand Test:
 - a. Automatic transfer switches utilizing solid-state devices in sensing, relaying, operating, or communication equipment or circuits shall comply with IEEE C37.90.1.
8. Housing:
 - a. Enclose automatic transfer switches in wall- or floor-mounted steel cabinets, with metal gauge not less than No. 14, in accordance with UL 508, or in a switchboard assembly in accordance with UL 891, as shown on the drawings.
 - b. Enclosure shall be constructed so that personnel are protected from energized bypass-isolation components during automatic transfer switch maintenance.

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- c. Automatic transfer switch components shall be removable without disconnecting external source or load power conductors.
 - d. Finish: Cabinets shall be given a phosphate treatment, painted with rust-inhibiting primer, and finish-painted with the manufacturer's standard enamel or lacquer finish.
 - e. Viewing Ports: Provide viewing ports so that contacts may be inspected without disassembly.
9. Operating Mechanism:
- a. Actuated by an electrical operator.
 - b. Electrically and mechanically interlocked so that the main contact cannot be closed simultaneously in either normal and emergency position.
 - c. Normal and emergency main contacts shall be mechanically locked in position by the operating linkage upon completion of transfer. Release of the locking mechanism shall be possible only by normal operating action.
 - d. Contact transfer time shall not exceed six cycles.
 - e. Operating mechanism components and mechanical interlocks shall be insulated or grounded.
10. Contacts:
- a. Main contacts: Silver alloy.
 - b. Neutral contacts: Silver alloy, with same current rating as phase contacts.
 - c. Current carrying capacity of arcing contacts shall not be used in the determination of the automatic transfer switch rating, and shall be separate from the main contacts.
 - d. Main and arcing contacts shall be visible for inspection with cabinet door open and barrier covers removed.
11. Manual Operator:
- a. Capable of operation by one person in either direction under no load.
12. Replaceable Parts:
- a. Include the main and arcing contacts individually or as units, as well as relays, and control devices.

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- b. Automatic transfer switch contacts and accessories shall be replaceable from the front without removing the switch from the cabinet and without removing main conductors.

13. Sensing Features:

- a. Undervoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100% of nominal, and dropout voltage is adjustable from 75 to 98% of pickup value. Factory set for pickup at 90% and dropout at 85%.
- b. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals. Adjustable from zero to six seconds, and factory set for one second.
- c. Voltage/Frequency Lockout Relay: Prevent premature transfer to the engine-generator. Pickup voltage shall be adjustable from 85 to 100% of nominal. Factory set for pickup at 90%. Pickup frequency shall be adjustable from 90 to 100% of nominal. Factory set for pickup at 95%.
- d. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes, and factory set for 10 minutes to automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
- e. Test Switch: Simulate normal-source failure.
- f. Switch-Position Indication: Indicate source to which load is connected.
- g. Source-Available Indication: Supervise sources via transfer switch normal- and emergency-source sensing circuits.
- h. Normal Power Indication: Indicate "Normal Source Available."
- i. Emergency Power Indication: Indicate "Emergency Source Available."
- j. Transfer Override Control: Overrides automatic retransfer control so that automatic transfer switch shall remain connected to emergency power source regardless of condition of normal source. Control panel shall indicate override status.
- k. Engine Starting Contacts: One isolated and normally closed and one isolated and normally open; rated 5 A at 30 V DC minimum.

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1. Engine Shutdown Contacts: Time delay adjustable from zero to 15 minutes, and factory set for 5 minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
- m. Engine-Generator Exerciser: Programmable exerciser starts engine-generator(s) and transfers load to them from normal source for a preset time, then retransfers and shuts down engine-generator(s) after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods are adjustable from 10 to 30 minutes. Factory settings shall be for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period.
14. Controls:
 - a. Controls shall provide indication of switch status and be equipped with alarm diagnostics.
 - b. Controls shall control operation of the automatic transfer switches.
15. Factory Wiring: Train and bundle factory wiring and label either by color-code or by numbered/lettered wire markers. Labels shall match those on the shop drawings.
16. Annunciation, Control, and Programming Interface Components:

Devices for communicating with remote programming devices, annunciators, or control panels and paralleling switchgear shall have open-protocol communication capability matched with remote device.
17. Provide contacts for connection to elevator controllers, one closed when automatic transfer switch is connected to the normal source, and one closed when automatic transfer switch is connected to the emergency source.
18. Motor Disconnect and Timing Relay: Controls designate starters so they disconnect motors before transfer and reconnect them selectively at an adjustable time interval after transfer. Control connection to motor starters is through wiring external to the automatic transfer switch. Time delay for reconnecting individual motor loads is adjustable between 1 and 60 seconds, and settings are

as indicated. Relay contacts handling motor-control circuit in-rush and seal currents are rated for actual currents to be encountered.

2.2 SEQUENCE OF OPERATION

- A. The specified voltage decrease in one or more phases of the normal power source shall initiate the transfer sequence. The automatic transfer switch shall start the engine-generator(s) after a specified time delay to permit override of momentary dips in the normal power source.
- B. The automatic transfer switch shall transfer the load from normal to emergency source when the frequency and voltage of the engine-generator(s) have attained the specified percent of rated value.
- C. Engine Start: A voltage decrease, at any automatic transfer switch, in one or more phases of the normal power source to less than the specified value of normal shall start the engine-generator(s) after a specified time delay.
- D. Transfer to Emergency System Loads: Automatic transfer switches for Emergency System loads shall transfer their loads from normal to emergency source when frequency and voltage of the engine-generator(s) have attained the specified percent of rated value. Only those switches with deficient normal source voltage shall transfer.
- E. Transfer to Equipment Branch Loads: Automatic transfer switches for Equipment Branch loads shall transfer their loads to the engine-generator on a time-delayed, staggered basis, after the Emergency System switches have transferred. Only those switches with deficient normal source voltage shall transfer.
- F. Retransfer to Normal (All Loads): Automatic transfer switches shall retransfer the load from emergency to normal source upon restoration of normal supply in all phases to the specified percent or more of normal voltage, and after a specified time delay. Should the emergency source fail during this time, the automatic transfer switches shall immediately transfer to the normal source whenever it becomes available. After restoring to normal source, the engine-generator(s) shall continue to run unloaded for a specified interval before shut-down.
 - a. Padlocking: Include provisions to padlock the isolating handle in the isolated position.

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- b. Visual verification: The isolation blades shall be visible in the isolated position.
- 2. Testing: It shall be possible to test (normal electrical operation) the automatic transfer switch and engine-generator(s) with the isolation contacts closed and the load bypassed without interruption of power to the load.
- G. Ratings: The electrical capabilities and ratings of the bypass-isolation switch shall be compatible with those of the associated automatic transfer switch, including any required additional withstand tests.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install automatic transfer switches in accordance with the NEC, as shown on the drawings, and as recommended by the manufacturer.
- B. Anchor automatic transfer switches with rustproof bolts, nuts, and washers not less than 12 mm (1/2 inch) diameter, in accordance with manufacturer's instructions, and as shown on drawings.
- C. Mount automatic transfer switches on concrete slab. Unless otherwise indicated, the slab shall be at least 100 mm (4 inches) thick. The top of the concrete slab shall be approximately 100 mm (4 inches) above finished floor. Edges above floor shall have 12.5 mm (1/2 inch) chamfer. The slab shall be of adequate size to project at least 100 mm (8 inches) beyond the equipment. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 75 mm (3 inches) above slab surface. Concrete work shall be as specified in Section 03 30 53, Short Form CAST-IN-PLACE CONCRETE.
- D. Anchor remote control and/or annunciator panel to wall.

3.2 ACCEPTANCE CHECKS AND TESTS

- A. An authorized representative of the automatic transfer switch manufacturer shall technically supervise and participate during all of the field adjustments and tests. Major adjustments and field tests shall be witnessed by the COR. The manufacturer's representative shall certify in writing that the equipment has been installed, adjusted and tested in accordance with the manufacturer's recommendations.

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B. Perform manufacturer's required field tests in accordance with the manufacturer's recommendations. In addition, include the following:

1. Visual Inspection and Tests:

- a. Compare equipment nameplate data with specifications and approved shop drawings.
- b. Inspect physical, electrical, and mechanical condition.
- c. Confirm correct application of manufacturer's recommended lubricants.
- d. Verify appropriate anchorage, required area clearances, and correct alignment.
- e. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method, or performing thermographic survey after energization.
- f. Verify grounding connections.
- g. Verify ratings of sensors.
- h. Vacuum-clean enclosure interior. Clean enclosure exterior.
- i. Exercise all active components.
- j. Verify that manual transfer warning signs are properly placed.
- k. Verify the correct operation of all sensing devices, alarms, and indicating devices.

2. Electrical tests:

- a. Perform insulation-resistance tests.
- b. After energizing circuits, demonstrate the interlocking sequence and operational function for each automatic transfer switch at least three times.
 - 1) Test bypass-isolation unit functional modes and related automatic transfer switch operations.
 - 2) Power failure of normal source shall be simulated by opening upstream protective device. This test shall be performed a minimum of five times.
 - 3) Power failure of emergency source with normal source available shall be simulated by opening upstream protective device for emergency source. This test shall be performed a minimum of five times.
 - 4) Low phase-to-ground voltage shall be simulated for each phase of normal source.

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- 5) Operation and settings shall be verified for specified automatic transfer switch operational feature, such as override time delay, transfer time delay, return time delay, engine shutdown time delay, exerciser, auxiliary contacts, and supplemental features.
- 6) Verify pickup and dropout voltages by data readout or inspection of control settings.
- 7) Verify that bypass and isolation functions perform correctly, including the physical removal of the automatic transfer switch while in bypass mode.
- c. Ground-fault tests: Verify that operation of automatic transfer switches shall not cause nuisance tripping or alarms of ground fault protection on either source.
- d. When any defects are detected, correct the defects and repeat the tests as requested by the COR at no additional cost to the Government.

3.3 FIELD SETTINGS VERIFICATION

- A. The automatic transfer switch settings shall be verified in the field by an authorized representative of the manufacturer.

3.4 FOLLOW-UP VERIFICATION

- A. Upon completion of acceptance checks and tests, the Contractor shall show by demonstration in service that the automatic transfer switches are in good operating condition and properly performing the intended function.

3.5 INSTRUCTION

- A. Furnish the services of a factory-trained technician for one 4-hour training period for instructing personnel in the maintenance and operation of the automatic transfer switches, on the dates requested by the COR

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SECTION 26 41 00
FACILITY LIGHTNING PROTECTION

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing and installation of a complete UL master labeled lightning protection system.

1.2 RELATED WORK

- A. Section 07 60 00, FLASHING AND SHEET METAL: Penetrations through the roof.
- B. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.
- C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path to ground for possible ground faults.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALIFICATIONS, (PRODUCTS AND SERVICES), in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. Submit the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
 - 1. Shop Drawings:
 - a. Submit sufficient information to demonstrate compliance with drawings and specifications.
 - b. Show locations of air terminals, connections to required metal surfaces, down conductors, and grounding means.
 - c. Show the mounting hardware and materials used to attach air terminals and conductors to the structure.
 - 2. Certifications: Two weeks prior to final inspection, submit the following.
 - a. Certification by the manufacturer that the lightning protection system conforms to the requirements of the drawings and specifications.
 - b. Certification by the Contractor that the lightning protection system has been properly installed and inspected.
 - c. Certification that the lightning protection system has been inspected by a UL representative and has been approved by UL without variation.

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1.5 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. National Fire Protection Association (NFPA):
- 70-14.....National Electrical Code (NEC)
 - 780-14.....Standard for the Installation of Lightning Protection Systems
- C. Underwriters Laboratories, Inc. (UL):
- 96-05.....Lightning Protection Components
 - 96A-07.....Installation Requirements for Lightning Protection Systems
 - 467-13.....Standard for Grounding and Bonding Equipment

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Lightning protection components shall conform to NFPA 780 and UL 96, for use on Class I structures. Aluminum materials are not allowed.
1. Class I conductors: Copper.
 2. Class I air terminals: Solid copper, 460 mm (18 inches) long, not less than 9.5 mm (3/8 inch) diameter, with sharp bare copper points.
 3. Ground rods: Copper-clad steel 0.75 in (19 mm) diameter by 3 m (10 feet) long.
 4. Ground plates: Solid copper, not less than 20 gauge.
 5. Bonding plates: Bronze, 50 square cm (8 square inches).
 6. Through roof connectors: Solid copper riser bar, length and type as required to accommodate roof structure and flashing requirements.
 7. Down conductor guards: Stiff copper or brass.
 8. Anchors and fasteners: Bronze bolt and clamp type shall be used for all applications except for membrane roof. Adhesive type are allowed only for attachment to membrane roof materials, using adhesive that is compatible with the membrane material.
 9. Connectors: Bronze clamp-type connectors shall be used for roof conductor splices, and the connection of the roof conductor to air

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terminals and bonding plates. Crimp-type connectors are not allowed.

10. Exothermic welds: Exothermic welds shall be used for splicing the roof conductor to the down conductors, splices of the down conductors, and for connection of the down conductors to ground rods, ground plates, and the ground ring.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall be coordinated with the roofing manufacturer and installer.
- B. Install the conductors as inconspicuously as practical.
- C. Install the down conductors within the concealed cavity of exterior walls where practical. Run the down conductors to the exterior at elevations below the finished grade.
- D. Where down conductors are subject to damage or are accessible near grade, protect with down conductor guards to 2.4 m (8 feet) above grade. Bond down conductor guards to down conductor at both ends.
- E. Make connections of dissimilar metal with bimetallic type fittings to prevent electrolytic action.
- F. Install ground rods and ground plates not less than 600 mm (2 feet) deep and a distance not less than 900 mm (3 feet) nor more than 2.5 m (8 feet) from the nearest point of the structure. Exothermically weld the down conductors to ground rods and ground plates in the presence of the Contracting Officers Representative (COR).
- G. Bond down conductors to metal main water piping where applicable.
- H. Bond down conductors to building structural steel.
- I. Connect roof conductors to all metallic projections and equipment above the roof as indicated on the drawings.
- J. Connect exterior metal surfaces, located within 900 mm (3 feet) of the conductors, to the conductors to prevent flashovers.
- K. Maintain horizontal or downward coursing of main conductor and insure that all bends have at least an 200 mm (8 inches) radius and do not exceed 90 degrees.
- L. Conductors shall be rigidly fastened every 900 mm (3 feet) along the roof and down to the building to ground.
- M. Air terminals shall be secured against overturning either by attachment

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to the object to be protected or by means of a substantial tripod or other braces permanently and rigidly attached to the building or structure.

- N. Install air terminal bases, cable holders and other roof-system supporting means without piercing membrane or metal roofs.
- O. Use through-roof connectors for penetration of the roof system. Flashing shall be provided by roofing contractor in accordance with Section 07 60 00, FLASHING AND SHEET METAL.
- P. Down conductors coursed on or in reinforced concrete columns or on structural steel columns shall be connected to the reinforcing steel or the structural steel member at its upper and lower extremities. In the case of long vertical members an additional connection shall be made at intervals not exceeding 30 M (100 feet).
- Q. A counterpoise or ground ring, where shown, shall be of No. 1/0 copper cable having suitable resistance to corrosion and shall be laid around the perimeter of the structure in a trench not less than 600 mm (2 feet) deep at a distance not less than 900 mm (3 feet) nor more than 2.5 M (8 feet) from the nearest point of the structure.
- R. On construction utilizing post tensioning systems to secure precast concrete sections, the post tension rods shall not be used as a path for lightning to ground.
- S. Where shown, use the structural steel framework or reinforcing steel as the down conductor.
 - 1. Weld or bond the non-electrically-continuous sections together and make them electrically continuous.
 - 2. Verify the electrical continuity by measuring the ground resistances to earth at the ground level, at the top of the building or stack, and at intermediate points with a sensitive ohmmeter. Compare the resistance readings.
 - 3. Connect the air terminals together with an exterior conductor connected to the structural steel framework at not more than 18 m (60 foot) intervals.
 - 4. Install ground connections to earth at not more than 18 m (60 foot) intervals around the perimeter of the building.
 - 5. Weld or braze bonding plates to cleaned sections of the steel and connect the conductors to the plates.

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6. Do not pierce the structural steel in any manner. Connections to the structural steel shall conform to UL 96A.
 - T. For obstruction lights, the following additional requirements shall apply:
 1. Extend air terminals 300 mm (1 foot) above the top of the light fixtures and securely clamp to the light fixture supports.
 2. Install 600 volt class lightning arresters. Connect the arresters to the lightning circuit conductors at suitable locations, and ground and bond them to the lightning protection system.
 - U. Where the drawings show the new lightning protection system connected to an existing lightning protection system with or without a UL master label, the new portion of the lightning protection system requires UL inspection and a Letter of Findings.
- 3.2 ACCEPTANCE CHECKS AND TESTS**
- A. Test the ground resistance to earth by standard methods, and conform to the ground resistance requirements specified in Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.
 - B. A UL representative shall inspect the lightning protection system. Obtain and install a UL numbered master label for each of the lightning protection systems at the location directed by the UL representative and the COR.

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SECTION 26 51 00
INTERIOR LIGHTING

PART 1 - GENERAL

1.1 DESCRIPTION:

- A. This section specifies the furnishing, installation, and connection of the interior lighting systems. The terms "lighting fixture," "fixture," and "luminaire" are used interchangeably.

1.2 RELATED WORK

- A. Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT: Disposal of lamps.
- B. Section 02 41 00, DEMOLITION: Removal and disposal of lamps and ballasts.
- C. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: Requirements that apply to all sections of Division 26.
- D. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Low-voltage conductors.
- E. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path to ground for possible ground fault currents.
- F. Section 26 27 26, WIRING DEVICES: Wiring devices used for control of the lighting systems.

1.2 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALIFICATIONS (PRODUCTS AND SERVICES), in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.3 SUBMITTALS

- A. Submit the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
 - 1. Shop Drawings:
 - a. Submit the following information for each type of lighting fixture designated on the LIGHTING FIXTURE SCHEDULE, arranged in order of lighting fixture designation.
 - b. Material and construction details, include information on housing and optics system.
 - c. Physical dimensions and description.
 - d. Wiring schematic and connection diagram.
 - e. Installation details.
 - f. Energy efficiency data.

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- g. Photometric data based on laboratory tests complying with IES Lighting Measurements testing and calculation guides.
 - h. Lamp data including lumen output (initial and mean), color rendition index (CRI), rated life (hours), and color temperature (degrees Kelvin).
 - i. Ballast data including ballast type, starting method, ambient temperature, ballast factor, sound rating, system watts, and total harmonic distortion (THD).
2. Manuals:
- a. Submit, simultaneously with the shop drawings, complete maintenance and operating manuals, including technical data sheets, wiring diagrams, and information for ordering replacement parts.
 - b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
3. Certifications: Two weeks prior to final inspection, submit the following.
- a. Certification by the Contractor that the interior lighting systems have been properly installed and tested.

1.4 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. American National Standards Institute (ANSI):
- C78.1-91.....Fluorescent Lamps - Rapid-Start Types -
Dimensional and Electrical Characteristics
 - C78.376-01.....Chromaticity of Fluorescent Lamps
- C. American Society for Testing and Materials (ASTM):
- C635-13.....Manufacture, Performance, and Testing of Metal
Suspension Systems for Acoustical Tile and Lay-
in Panel Ceilings
- D. Environmental Protection Agency (EPA):
- 40 CFR 261.....Identification and Listing of Hazardous Waste

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E. Federal Communications Commission (FCC):

CFR Title 47, Part 15...Radio Frequency Devices

CFR Title 47, Part 18...Industrial, Scientific, and Medical Equipment

F. Illuminating Engineering Society (IES):

LM-79-08.....Electrical and Photometric Measurements of
Solid-State Lighting Products

LM-80-08.....Measuring Lumen Maintenance of LED Light
Sources

LM-82-12.....Characterization of LED Light Engines and LED
Lamps for Electrical and Photometric Properties
as a Function of Temperature

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

C62.41-08.....Surge Voltages in Low Voltage AC Power Circuits

H. International Code Council (ICC):

IBC-15.....International Building Code

I. National Fire Protection Association (NFPA):

70-14.....National Electrical Code (NEC)

101-15.....Life Safety Code

J. National Electrical Manufacturer's Association (NEMA):

C82.1-04.....Lamp Ballasts - Line Frequency Fluorescent Lamp
Ballasts

C82.2-02.....Method of Measurement of Fluorescent Lamp
Ballasts

C82.4-02.....Lamp Ballasts - Ballasts for High-Intensity
Discharge and Low-Pressure Sodium (LPS) Lamps
(Multiple-Supply Type)

C82.11-11.....Lamp Ballasts - High Frequency Fluorescent Lamp
Ballasts

K. Underwriters Laboratories, Inc. (UL):

496-08.....Lampholders

542-0599.....Fluorescent Lamp Starters

924-12.....Emergency Lighting and Power Equipment

935-01.....Fluorescent-Lamp Ballasts

1029-94.....High-Intensity-Discharge Lamp Ballasts

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1029A-06.....Ignitors and Related Auxiliaries for HID Lamp
Ballasts
1598-08.....Luminaires
1574-04.....Track Lighting Systems
2108-04.....Low-Voltage Lighting Systems
8750-09.....Light Emitting Diode (LED) Light Sources for
Use in Lighting Products

PART 2 - PRODUCTS

2.1 LIGHTING FIXTURES

- A. Shall be in accordance with NFPA, UL, as shown on drawings, and as specified.
- B. Sheet Metal:
 - 1. Shall be formed to prevent warping and sagging. Housing, trim and lens frame shall be true, straight (unless intentionally curved), and parallel to each other as designed.
 - 2. Wireways and fittings shall be free of burrs and sharp edges, and shall accommodate internal and branch circuit wiring without damage to the wiring.
 - 3. When installed, any exposed fixture housing surface, trim frame, door frame, and lens frame shall be free of light leaks.
 - 4. Hinged door frames shall operate smoothly without binding. Latches shall function easily by finger action without the use of tools.
- C. Ballasts and lamps shall be serviceable while the fixture is in its normally installed position. Ballasts shall not be mounted to removable reflectors or wireway covers unless so specified.
- D. Recessed fixtures mounted in an insulated ceiling shall be listed for use in insulated ceilings.
- E. Mechanical Safety: Lighting fixture closures (lens doors, trim frame, hinged housings, etc.) shall be retained in a secure manner by captive screws, chains, aircraft cable, captive hinges, or fasteners such that they cannot be accidentally dislodged during normal operation or routine maintenance.
- F. Metal Finishes:
 - 1. The manufacturer shall apply standard finish (unless otherwise specified) over a corrosion-resistant primer, after cleaning to free

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the metal surfaces of rust, grease, dirt and other deposits. Edges of pre-finished sheet metal exposed during forming, stamping or shearing processes shall be finished in a similar corrosion resistant manner to match the adjacent surface(s). Fixture finish shall be free of stains or evidence of rusting, blistering, or flaking, and shall be applied after fabrication.

2. Interior light reflecting finishes shall be white with not less than 85 percent reflectances, except where otherwise shown on the drawing.

3. Exterior finishes shall be as shown on the drawings.

G. Lighting fixtures shall have a specific means for grounding metallic wireways and housings to an equipment grounding conductor.

1. Flat lens panels shall have not less than 3 mm (1/8 inch) of average thickness.

2. Unless otherwise specified, lenses, reflectors, diffusers, and louvers shall be retained firmly in a metal frame by clips or clamping ring in such a manner as to allow expansion and contraction without distortion or cracking.

2.7 LED EXIT LIGHT FIXTURES

A. Exit light fixtures shall meet applicable requirements of NFPA and UL.

B. Housing and door shall be die-cast aluminum.

C. For general purpose exit light fixtures, door frame shall be hinged, with latch. For vandal-resistant exit light fixtures, door frame shall be secured with tamper-resistant screws.

D. Finish shall be satin or fine-grain brushed aluminum.

E. There shall be no radioactive material used in the fixtures.

F. Fixtures:

1. Inscription panels shall be cast or stamped aluminum a minimum of 2.25 mm (0.090 inch) thick, stenciled with 150 mm (6 inch) high letters, baked with red color stable plastic or fiberglass. Lamps shall be luminous Light Emitting Diodes (LED) mounted in center of letters on red color stable plastic or fiberglass.

2. Double-Faced Fixtures: Provide double-faced fixtures where required or as shown on drawings.

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3. Directional Arrows: Provide directional arrows as part of the inscription panel where required or as shown on drawings.
Directional arrows shall be the "chevron-type" of similar size and width as the letters and meet the requirements of NFPA 101.

G. Voltage: Multi-voltage (120 - 277V).

2.8 LED LIGHT FIXTURES

A. General:

1. LED light fixtures shall be in accordance with IES, NFPA, UL, as shown on the drawings, and shall be DLC (DesignLights Consortium) listed or approved equal as specified.
2. LED light fixtures shall be Reduction of Hazardous Substances (RoHS)-compliant.
3. LED drivers shall include the following features unless otherwise indicated:
 - a. Minimum efficiency: 85% at full load.
 - b. Minimum Operating Ambient Temperature: -20° C. (-4° F.)
 - c. Input Voltage: 120 - 277V (±10%) at 60 Hz.
 - d. Integral short circuit, open circuit, and overload protection.
 - e. Power Factor: ≥ 0.95.
 - f. Total Harmonic Distortion: ≤ 20%.
 - g. Comply with FCC 47 CFR Part 15.
4. LED modules shall include the following features unless otherwise indicated:
 - a. Comply with IES LM-79 and LM-80 requirements.
 - b. Minimum CRI 80 and color temperature 3000° K unless otherwise specified in LIGHTING FIXTURE SCHEDULE.
 - c. Minimum Rated Life: 50,000 hours per IES L70.
 - d. Light output lumens as indicated in the LIGHTING FIXTURE SCHEDULE.

B. LED Downlights:

1. Housing, LED driver, and LED module shall be products of the same manufacturer.

C. LED Troffers:

1. LED drivers, modules, and reflector shall be accessible, serviceable, and replaceable from below the ceiling.

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2. Housing, LED driver, and LED module shall be products of the same manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Installation shall be in accordance with the NEC, manufacturer's instructions, and as shown on the drawings or specified.
- B. Align, mount, and level the lighting fixtures uniformly.
- C. Wall-mounted fixtures shall be attached to the studs in the walls, or to a 20 gauge metal backing plate that is attached to the studs in the walls. Lighting fixtures shall not be attached directly to gypsum board.
- D. Lighting Fixture Supports:
 1. Shall provide support for all of the fixtures. Supports may be anchored to channels of the ceiling construction, to the structural slab or to structural members within a partition, or above a suspended ceiling.
 2. Shall maintain the fixture positions after cleaning and relamping.
 3. Shall support the lighting fixtures without causing the ceiling or partition to deflect.
 - a. Fixtures less than 6.8 kg (15 pounds) in weight and occupying less than 3715 sq cm (two square feet) of ceiling area may, when designed for the purpose, be supported directly from the outlet box when all the following conditions are met.
 - 1) Screws attaching the fixture to the outlet box pass through round holes (not key-hole slots) in the fixture body.
 - 2) The outlet box is attached to a main ceiling runner (or cross runner) with approved hardware.
 - 3) The outlet box is supported vertically from the building structure.
 - b. Fixtures mounted in open construction shall be secured directly to the building structure with approved bolting and clamping devices.
 4. Single or double pendant-mounted lighting fixtures:
 - a. Each stem shall be supported by an approved outlet box mounted swivel joint and canopy which holds the stem captive and

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provides spring load (or approved equivalent) dampening of fixture oscillations. Outlet box shall be supported vertically from the building structure.

5. Outlet boxes for support of lighting fixtures (where permitted) shall be secured directly to the building structure with approved devices or supported vertically in a hung ceiling from the building structure with a nine gauge wire hanger, and be secured by an approved device to a main ceiling runner or cross runner to prevent any horizontal movement relative to the ceiling.//
- E. Furnish and install the new lamps as specified for all lighting fixtures installed under this project, and for all existing lighting fixtures reused under this project.
- F. The electrical and ceiling trades shall coordinate to ascertain that approved lighting fixtures are furnished in the proper sizes and installed with the proper devices (hangers, clips, trim frames, flanges, etc.), to match the ceiling system being installed.
- G. Bond lighting fixtures to the grounding system as specified in Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.
- H. At completion of project, replace all defective components of the lighting fixtures at no cost to the Government.
- I. Dispose of lamps per requirements of Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT, and Section 02 41 00, DEMOLITION.

3.2 ACCEPTANCE CHECKS AND TESTS

- A. Perform the following:
 1. Visual Inspection:
 - a. Verify proper operation by operating the lighting controls.
 - b. Visually inspect for damage to fixtures, lenses, reflectors, diffusers, and louvers. Clean fixtures, lenses, reflectors, diffusers, and louvers that have accumulated dust, dirt, or fingerprints during construction.
 2. Electrical tests:
 - a. Exercise dimming components of the lighting fixtures over full range of dimming capability by operating the control devices(s) in the presence of the Contracting Officers Representative (COR) Observe for visually detectable flicker

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over full dimming range, and replace defective components at no cost to the Government.

- b. Burn-in all lamps that require specific aging period to operate properly, prior to occupancy by Government. Burn-in period to be 40 hours minimum, unless specifically recommended otherwise by the lamp manufacturer. Burn-in dimmed fluorescent and compact fluorescent lamps for at least 100 hours at full voltage, unless specifically recommended otherwise by the lamp manufacturer. Replace any lamps and ballasts which fail during burn-in.

3.3 FOLLOW-UP VERIFICATION

- A. Upon completion of acceptance checks and tests, the Contractor shall show by demonstration in service that the lighting systems are in good operating condition and properly performing the intended function.

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SECTION 26 56 00
EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section specifies the furnishing, installation, and connection of exterior luminaires, poles, and supports.

1.2 RELATED WORK

- A. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements and items that are common to more than one section of Division 26.
- B. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES: Low voltage power and lighting wiring.
- C. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.
- D. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits, fittings, and boxes for raceway systems.
- E. Section 26 09 23, LIGHTING CONTROLS: Controls for exterior lighting.

1.3 QUALITY ASSURANCE

- A. Refer to Paragraph, QUALIFICATIONS, in Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

1.4 SUBMITTALS

- A. Submit the following in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
1. Shop Drawings:
- a. Submit the following information for each type of lighting fixture designated on the LIGHTING FIXTURE SCHEDULE, arranged in order of lighting fixture designation.
 - b. Material and construction details, include information on housing and optics system.
 - c. Physical dimensions and description.
 - d. Wiring schematic and connection diagram.
 - e. Installation details.
 - f. Energy efficiency data.

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- g. Photometric data based on laboratory tests complying with IES Lighting Measurements testing and calculation guides.
 - h. Lamp data including lumen output (initial and mean), color rendition index (CRI), rated life (hours), and color temperature (degrees Kelvin).
 - i. Ballast data including ballast type, starting method, ambient temperature, ballast factor, sound rating, system watts, and total harmonic distortion (THD).
 - j. For LED lighting fixtures, submit US DOE LED Lighting Facts label, and IES L70 rated life.
2. Manuals:
- a. Submit, simultaneously with the shop drawings, complete maintenance and operating manuals, including technical data sheets, wiring diagrams, and information for ordering replacement parts.
 - b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
3. Certifications: Two weeks prior to final inspection, submit the following.
- a. Certification by the Contractor that the exterior lighting systems have been properly installed and tested.

1.5 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.
- B. Aluminum Association Inc. (AA):
AAH35.1-06.....Alloy and Temper Designation Systems for
Aluminum
- C. American Association of State Highway and Transportation Officials (AASHTO):
32-LTS-6.....Structural Supports for Highway Signs,
Luminaires and Traffic Signals
- D. American Concrete Institute (ACI):

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318-05Building Code Requirements for Structural
Concrete

E. American National Standards Institute (ANSI):

C81.61-09Electrical Lamp Bases - Specifications for
Bases (Caps) for Electric Lamps

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

A123/A123M-12Zinc (Hot-Dip Galvanized) Coatings on Iron and
Steel Products

A153/A153M-09.....Zinc Coating (Hot-Dip) on Iron and Steel
Hardware

B108-03a-08Aluminum-Alloy Permanent Mold Castings

C1089-13Spun Cast Prestressed Concrete Poles

G. Federal Aviation Administration (FAA):

AC 70/7460-IK-07.....Obstruction Lighting and Marking

AC 150/5345-43F-06.....Obstruction Lighting Equipment

H. Illuminating Engineering Society of North America (IESNA):

HB-9-00.....Lighting Handbook

RP-8-05.....Roadway Lighting

LM-52-03.....Photometric Measurements of Roadway Sign
Installations

LM-72-10.....Directional Positioning of Photometric Data

LM-79-08.....Approved Method for the Electrical and
Photometric Measurements of Solid-State Lighting
Products

LM-80-08.....Approved Method for Measuring Lumen Maintenance
of LED Light Sources

TM-15-07.....Backlight, Uplight and Glare (BUG) Ratings

I. National Electrical Manufacturers Association (NEMA):

C78.41-06.....Electric Lamps - Guidelines for Low-Pressure
Sodium Lamps

C78.42-07Electric Lamps - Guidelines for High-Pressure
Sodium Lamps

C78.43-07Electric Lamps - Single-Ended Metal-Halide
Lamps

C78.1381-98.....Electric Lamps - 70-Watt M85 Double-Ended
Metal-Halide Lamps

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C82.4-02Ballasts for High-Intensity-Discharge and Low-
Pressure Sodium Lamps (Multiple-Supply Type)

C136.3-05For Roadway and Area Lighting Equipment -
Luminaire Attachments

C136.17-05Roadway and Area Lighting Equipment - Enclosed
Side-Mounted Luminaires for Horizontal-Burning
High-Intensity-Discharge Lamps - Mechanical
Interchangeability of Refractors

ICS 2-00 (R2005)Controllers, Contactors and Overload Relays
Rated 600 Volts

ICS 6-93 (R2006)Enclosures

J. National Fire Protection Association (NFPA):

70-14National Electrical Code (NEC)

K. Underwriters Laboratories, Inc. (UL):

496-08Lampholders

773-95.....Plug-In, Locking Type Photocontrols for Use
with Area Lighting

773A-06Nonindustrial Photoelectric Switches for
Lighting Control

1029-94.....High-Intensity-Discharge Lamp Ballasts

1598-08Luminaires

8750-09.....Light Emitting Diode (LED) Equipment for Use in
Lighting Products

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Provide manufacturer's standard provisions for protecting pole finishes during transport, storage, and installation. Do not store poles on ground. Store poles so they are at least 12 in [305 mm] above ground level and growing vegetation. Do not remove factory-applied pole wrappings until just before installing pole.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

- A. Luminaires, materials and equipment shall be in accordance with NEC, UL, ANSI, and as shown on the drawings and specified.

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2.2 LUMINAIRES

- A. Per UL 1598 and NEMA C136.17. Luminaires shall be weatherproof, heavy duty, outdoor types designed for efficient light utilization, adequate dissipation of lamp and ballast heat, and safe cleaning and relamping.
- B. Light distribution pattern types shall be as shown on the drawings.
- C. Incorporate ballasts in the luminaire housing, except where otherwise shown on the drawings.
- D. Lenses shall be frame-mounted, heat-resistant, borosilicate glass, with prismatic refractors, unless otherwise shown on the drawings. Attach the frame to the luminaire housing by hinges or chain. Use heat and aging-resistant, resilient gaskets to seal and cushion lenses and refractors in luminaire doors.
- E. Pre-wire internal components to terminal strips at the factory.
- F. Bracket-mounted luminaires shall have leveling provisions and clamp-type adjustable slip-fitters with locking screws.
- G. Materials shall be rustproof. Latches and fittings shall be non-ferrous metal.
- H. Provide manufacturer's standard finish, as scheduled on the drawings. Where indicated on drawings, match finish process and color of pole or support materials. Where indicated on drawings, provide finishes as indicated in Section 09 06 00, SCHEDULE FOR FINISHES.
- I. Luminaires shall carry factory labels, showing complete, specific lamp and ballast information.

2.3 LAMPS

- A. Install the proper lamps in every luminaire installed as shown on the drawings.
- B. Lamps shall be general-service, outdoor lighting types.
- C. LED sources shall meet the following requirements:
 - 1. Operating temperature rating shall be between -40 degrees C (-40 degrees F) and 50 degrees C (120 degrees F).
 - 2. Correlated Color Temperature (CCT): 3500K.
 - 3. Color Rendering Index (CRI): ≥ 85 .
 - 4. The manufacturer shall have performed reliability tests on the LEDs luminaires complying with Illuminating Engineering Society (IES) LM79 for photometric performance and LM80 for lumen maintenance and L70 life.

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5. LED luminaires shall be DLC (DesignLight Consortium) listed or approved equal.

D. Mercury vapor lamps shall not be used.

2.4 LED DRIVERS

A. LED drivers shall meet the following requirements:

1. Drivers shall have a minimum efficiency of 85%.
2. Starting Temperature: -40° F [-40° C].
3. Input Voltage: 120 to 480 ($\pm 10\%$) V.
4. Power Supplies: Class I or II output.
5. Surge Protection: The system must survive 250 repetitive strikes of "C Low" (C Low: $6\text{kV}/1.2 \times 50\text{ }\mu\text{s}$, $10\text{kA}/8 \times 20\text{ }\mu\text{s}$) waveforms at 1-minute intervals with less than 10% degradation in clamping voltage. "C Low" waveforms are as defined in IEEE/ASNI C62.41.2-2002, Scenario 1 Location Category C.
6. Power Factor (PF): ≥ 0.90 .
7. Total Harmonic Distortion (THD): $\leq 20\%$.
8. Comply with FCC Title 47 CFR Part 18 Non-consumer RFI/EMI Standards.
9. Drivers shall be reduction of hazardous substances (ROHS)-compliant.

2.5 OBSTRUCTION LIGHTING

A. Refer to Section 26 09 23, LIGHTING CONTROLS for control devices.

B. For Buildings:

1. LED type luminaires shall comply with FAA, AC 70/7460-1K, and AC 150/5345-53, and be Type L-810 duplex units with red steady burning light from and LED light source with minimum 50,000 hour lamp life and employing Night Vision Goggles (NVG) friendly technology.
2. Mount the luminaires on galvanized rigid steel pipe masts attached to the roof of the buildings so the luminaires extend 305 mm (12 inches) above the level of the highest item on the building, including items attached to the roof.
3. Locate luminaires in accordance with the applicable FAA Standards.

C. For Smoke Stacks: Luminaires shall be in accordance with the referenced details shown on the drawings. All lamps shall be the type shown on the drawings.

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PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install lighting in accordance with the NEC, as shown on the drawings, and in accordance with manufacturer's recommendations.

3.2 GROUNDING

- A. Ground noncurrent-carrying parts of equipment, luminaires, mounting arms, brackets, and metallic enclosures, as specified in Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS. Where copper grounding conductor is connected to a metal other than copper, provide specially-treated or lined connectors suitable and listed for this purpose.

3.3 ACCEPTANCE CHECKS AND TESTS

- A. Verify operation after installing luminaires and energizing circuits.

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SECTION 28 31 00
FIRE DETECTION AND ALARM

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This section of the specifications includes the furnishing, installation, and connection of the fire alarm equipment to form a complete coordinated system ready for operation. It shall include, but not be limited to, alarm initiating devices, alarm notification appliances, control units, fire safety control devices, power supplies, and wiring as shown on the drawings and specified. The fire alarm system shall not be combined with other systems such as building automation, energy management, security, etc.
- B. Fire alarm systems shall comply with requirements of the most recent VA FIRE PROTECTION DESIGN MANUAL and NFPA 72 unless variations to NFPA 72 are specifically identified within these contract documents by the following notation: "variation". The design, system layout, document submittal preparation, and supervision of installation and testing shall be provided by a technician that is certified NICET level III or a registered fire protection engineer. The NICET certified technician shall be on site for the supervision and testing of the system. Factory engineers from the equipment manufacturer, thoroughly familiar and knowledgeable with all equipment utilized, shall provide additional technical support at the site as required by the Contracting Officers Representative (COR) or his authorized representative. Installers shall have a minimum of 2 years experience installing fire alarm systems.
- C. All existing fire alarm equipment, wiring, devices and sub-systems that are not shown to be reused shall be removed. All existing fire alarm conduit not reused shall be removed.
- D. 120VAC duct smoke detectors, may be reused only as specifically indicated on the drawings and provided the equipment meets this specification section.
- E. Is UL listed or FM approved.
- F. Is compatible with new equipment being installed.
- G. Is verified as operable through contractor testing and inspection.
- H. Is warranted as new by the contractor.

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1.2 SUBMITTALS

- A. General: Submit 5 copies in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES, and Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
- B. Prepare drawings using AutoCAD Release 14 software and include all contractors information. Layering shall be by VA criteria as provided by the Contracting Officer's Technical Representative (COR). Bid drawing files on AutoCAD will be provided to the Contractor at the pre-construction meeting. The contractor shall be responsible for verifying all critical dimensions shown on the drawings provided by VA.
- C. Floor plans: Provide locations of all devices (with device number at each addressable device corresponding to control unit programming), appliances, panels, equipment, junction/terminal cabinets/boxes, risers, electrical power connections, individual circuits and raceway routing, system zoning; number, size, and type of raceways and conductors in each raceway; conduit fill calculations with cross section area percent fill for each type and size of conductor and raceway. Only those devices connected and incorporated into the final system shall be on these floor plans. Do not show any removed devices on the floor plans. Show all interfaces for all fire safety functions.
- D. Two weeks prior to final inspection, the Contractor shall deliver to the COR 3 sets of as-built drawings and one set of the as-built drawing computer files (using AutoCAD 2007 or later). As-built drawings (floor plans) shall show all new and/or existing conduit used for the fire alarm system.
- E. Submit simultaneously with the shop drawings, companion copies of complete maintenance and operating manuals including technical data sheets for all items used in the system, power requirements, device wiring diagrams, dimensions, and information for ordering replacement parts.
- F. Wiring diagrams shall have their terminals identified to facilitate installation, operation, expansion and maintenance.
- G. Wiring diagrams shall indicate internal wiring for each item of equipment and the interconnections between the items of equipment.
- H. Include complete listing of all software used and installation and operation instructions including the input/output matrix chart.

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- I. Provide a clear and concise description of operation that gives, in detail, the information required to properly operate, inspect, test and maintain the equipment and system. Provide all manufacturer's installation limitations including but not limited to circuit length limitations.
- J. Complete listing of all digitized voice messages.
- K. Provide standby battery calculations under normal operating and alarm modes. Battery calculations shall include the magnets for holding the doors open for one minute.
- L. Include information indicating who will provide emergency service and perform post contract maintenance.
- M. Provide a replacement parts list with current prices. Include a list of recommended spare parts, tools, and instruments for testing and maintenance purposes.
- N. A computerized preventive maintenance schedule for all equipment. The schedule shall be provided on disk in a computer format acceptable to the VAMC and shall describe the protocol for preventive maintenance of all equipment. The schedule shall include the required times for systematic examination, adjustment and cleaning of all equipment. A print out of the schedule shall also be provided in the manual. Provide the disk in a pocket within the manual.
- O. Furnish manuals in 3 ring loose-leaf binder or manufacturer's standard binder.
- P. A print out for all devices proposed on each signaling line circuit with spare capacity indicated.
- Q. Two weeks prior to final inspection, deliver 4 copies of the final updated maintenance and operating manual to the COR.
- R. The manual shall be updated to include any information necessitated by the maintenance and operating manual approval.
 - A. Complete "As installed" wiring and schematic diagrams shall be included that shows all items of equipment and their interconnecting wiring. Show all final terminal identifications.
 - B. Complete listing of all programming information, including all control events per device including an updated input/output matrix.

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- C. Certificate of Installation as required by NFPA 72 for each building. The certificate shall identify any variations from the National Fire Alarm Code.
- D. Certificate from equipment manufacturer assuring compliance with all manufacturers installation requirements and satisfactory system operation.
- E. Certifications:
- F. Together with the shop drawing submittal, submit the technician's NICET level III fire alarm certification as well as certification from the control unit manufacturer that the proposed performer of contract maintenance is an authorized representative of the major equipment manufacturer. Include in the certification the names and addresses of the proposed supervisor of installation and the proposed performer of contract maintenance. Also include the name and title of the manufacturer's representative who makes the certification.
- G. Together with shop drawing submittal, submit a certification from either the control unit manufacturer or the manufacturer of each component (e.g., smoke detector) that the components being furnished are compatible with the control unit.
- H. Together with the shop drawing submittal, submit a certification from the major equipment manufacturer that the wiring and connection diagrams meet this specification, UL and NFPA 72 requirements.
- I. Warranty
- J. 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 Contracting Officer.

1.3 GUARANTY PERIOD SERVICES

- A. Complete inspection, testing, maintenance and repair service for the fire alarm system shall be provided by a factory trained authorized representative of the manufacturer of the major equipment for a period of 5 years from the date of acceptance of the entire installation by the Contracting Officer.

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- B. Contractor shall provide all necessary test equipment, parts and labor to perform required inspection, testing, maintenance and repair.
- C. All inspection, testing, maintenance and permanent records required by NFPA 72, and recommended by equipment manufacturer shall be provided by the contractor. Work shall include reused existing equipment connected to the fire alarm system. It shall include all interfaced equipment including but not limited to elevators, HVAC shutdown, and extinguishing systems.
- D. Maintenance and testing shall be performed in accordance with NFPA 72. A computerized preventive maintenance schedule shall be provided and shall describe the protocol for preventive maintenance of equipment. The schedule shall include a systematic examination, adjustment and cleaning of all equipment.
- E. Non-included Work: Repair service shall not include the performance of any work due to improper use, accidents, or negligence for which the contractor is not responsible.
- F. Service and emergency personnel shall report to the Engineering Office or their authorized representative upon arrival at the hospital and again upon the completion of the required work. A copy of the work ticket containing a complete description of the work performed and parts replaced shall be provided to the VA COR or his authorized representative.
- G. Emergency Service:
- H. Warranty Period Service: Service other than the preventative maintenance, inspection, and testing required by NFPA 72 shall be considered emergency call-back service and covered under the warranty of the installation during the first year of the warranty period, unless the required service is a result of abuse or misuse by the Government. Written notification shall not be required for emergency warranty period service and the contractor shall respond as outlined in the following sections on Normal and Overtime Emergency Call-Back Service. Warranty period service can be required during normal or overtime emergency call-back service time periods at the discretion of the COR or his authorized representative.

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- #### 1.4 APPLICABLE PUBLICATIONS

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NFPA 72.....National Fire Alarm Code, 2016 edition
NFPA 90A.....Standard for the Installation of Air
Conditioning and Ventilating Systems, 2015
edition

NFPA 101.....Life Safety Code, 2015 edition

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

D. Factory Mutual Research Corp (FM): Approval Guide, 2007-2011

E. American National Standards Institute (ANSI):

S3.41.....Audible Emergency Evacuation Signal, 1990
edition, reaffirmed 2008

F. International Code Council, International Building Code (IBC), 2009
edition

PART 2 - PRODUCTS

2.1 EQUIPMENT AND MATERIALS, GENERAL

- A. Existing equipment may be reused only where indicated on the drawings.
- B. Except as indicated in paragraph A above, All equipment and components shall be new and the manufacturer's current model. All equipment shall be tested and listed by Underwriters Laboratories, Inc. or Factory Mutual Research Corporation for use as part of a fire alarm system. 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 CONDUIT, BOXES, AND WIRE

- A. Conduit shall be as follows:
 - 1. All new and reused conduit shall be installed in accordance with NFPA 70.
 - 2. Conduit fill shall not exceed 40 percent of interior cross sectional area.
 - 3. All new conduit shall be 3/4 inch minimum.
- B. Wire:
 - 1. All existing wiring shall be removed and new wiring installed in a conduit or raceway.
 - 2. Wiring shall be in accordance with NEC article 760, and as recommended by the manufacturer of the fire alarm system. All wires

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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 device circuits.

3. Addressable circuits and wiring used for the multiplex communication loop shall be twisted and shielded unless specifically accepted by the fire alarm equipment manufacturer in writing.
4. Any fire alarm system wiring that extends outside of a building shall have additional power surge protection to protect equipment from physical damage and false signals due to lightning, voltage and current induced transients. Protection devices shall be shown on the submittal drawings and shall be UL listed or in accordance with written manufacturer's requirements.
5. All wire or cable used in underground conduits including those in concrete shall be listed for wet locations.

C. Terminal Boxes, Junction Boxes, and Cabinets:

1. Shall be galvanized steel in accordance with UL requirements.
2. All new and reused boxes shall be sized and installed in accordance with NFPA 70.
3. New and existing covers shall be repainted red in accordance with Section 09 91 00, PAINTING and shall be identified with white markings as "FA" for junction boxes and as "FIRE ALARM SYSTEM" for cabinets and terminal boxes. Lettering shall be a minimum of 3/4 inch (19 mm) high.
4. Terminal boxes and cabinets shall have a volume 50 percent greater than required by the NFPA 70. Minimum sized wire shall be considered as 14 AWG for calculation purposes.
5. Terminal boxes and cabinets shall have identified pressure type terminal strips and shall be located at the base of each riser. Terminal strips shall be labeled as specified or as approved by COR.

2.3 ALARM NOTIFICATION APPLIANCES

A. Strobes:

1. Xenon flash tube type minimum 15 candela in toilet rooms and 75 candela in all other areas with a flash rate of 1 HZ. Strobes shall be synchronized where required by the National Fire Alarm Code (NFPA 72).

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2. Backplate shall be red with 1/2 inch (13 mm) permanent red letters. Lettering to read "Fire", be oriented on the wall or ceiling properly, and be visible from all viewing directions.
3. Each strobe circuit shall have a minimum of 20 percent spare capacity.
4. Strobes may be combined with the audible notification appliances specified herein.

B. Fire Alarm Horns:

1. Shall be electric, utilizing solid state electronic technology operating on a nominal 24 VDC.
2. Shall be a minimum nominal rating of 80 dBA at 10 feet (3,000 mm).
3. Mount on removable adapter plates on conduit boxes.
4. Horns located outdoors shall be of weatherproof type with metal housing and protective grille.
5. Each horn circuit shall have a minimum of 20 percent spare capacity.

2.4 ALARM INITIATING DEVICES

A. Manual Fire Alarm Stations:

1. Shall be non-breakglass, address reporting type.
2. Station front shall be constructed of a durable material such as cast or extruded metal or high impact plastic. Stations shall be semi-flush type.
3. Stations shall be of single action pull down type with suitable operating instructions provided on front in raised or depressed letters, and clearly labeled "FIRE".
4. Operating handles shall be constructed of a durable material. On operation, the lever shall lock in alarm position and remain so until reset. A key shall be required to gain front access for resetting, or conducting tests and drills.
5. Unless otherwise specified, all exposed parts shall be red in color and have a smooth, hard, durable finish.

B. Smoke Detectors:

1. Smoke detectors shall be photoelectric type and UL listed for use with the fire alarm control unit being furnished.
2. Smoke detectors shall be addressable type complying with applicable UL Standards for system type detectors. Smoke detectors shall be

installed in accordance with the manufacturer's recommendations and NFPA 72.

3. Detectors shall have an indication lamp to denote an alarm condition. Provide remote indicator lamps and identification plates where detectors are concealed from view. Locate the remote indicator lamps and identification plates flush mounted on walls so they can be observed from a normal standing position.
4. All spot type and duct type detectors installed shall be of the photoelectric type.
5. 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.
6. Detectors shall provide a visual trouble indication if they drift out of sensitivity range or fail internal diagnostics. Detectors shall also provide visual indication of sensitivity level upon testing. Detectors, along with the fire alarm control units shall be UL listed for testing the sensitivity of the detectors.

C. Heat Detectors:

1. Heat detectors shall be of the addressable restorable rate compensated fixed-temperature spot type.
2. Detectors shall have a minimum smooth ceiling rating of 2,500 square feet (230 square meters).
3. Ordinary temperature (135 degrees F (57 degrees C)) heat detectors shall be utilized in elevator mechanical rooms. Intermediate temperature rated (200 degrees F (93 degrees C)) heat detectors shall be utilized in all other areas.

2.5 SUPERVISORY DEVICES

A. Duct Smoke Detectors:

1. Duct smoke detectors shall be provided and connected by way of an address reporting interface device. Detectors shall be provided with an approved duct housing mounted exterior to the duct, and shall have perforated sampling tubes extending across the full width of the duct (wall to wall). Detector placement shall be such that there is uniform airflow in the cross section of the duct.

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2. Interlocking with fans shall be provided in accordance with NFPA 90A and as specified hereinafter under Part 3.2, "TYPICAL OPERATION."
3. Provide remote indicator lamps, key test stations and identification nameplates (e.g. "DUCT SMOKE DETECTOR AHU-X") for all duct detectors. Locate key test stations in plain view on walls or ceilings so that they can be observed and operated from a normal standing position.
4. Fire supervisory signals required by NFPA 20 and monitored by the pump controller shall be provided and monitored by way of address reporting interface devices for the fire pump location.

2.6 SPARE AND REPLACEMENT PARTS

- A. Provide spare and replacement parts as follows:
 1. Manual pull stations - 5
 2. Heat detectors - 2 of each type
 3. Fire alarm strobes - 5
 4. Smoke detectors - 20
 5. Duct smoke detectors with all appurtenances - 1
 6. Fire alarm SLC cable (same as installed) - 500 feet (152 m)
- B. Spare and replacement parts shall be in original packaging and submitted to the COR.
- C. Furnish and install a storage cabinet of sufficient size and suitable for storing spare equipment. Doors shall include a pad locking device. Padlock to be provided by the VA. Location of cabinet to be determined by the COR.
- D. Provide to the VA, all hardware, software, programming tools, license and documentation necessary to permanently modify the fire alarm system on site. The minimum level of modification includes addition and deletion of devices, circuits, zones and changes to system description, system operation, and digitized evacuation and instructional messages.

2.7 INSTRUCTION CHART:

Provide a typewritten instruction card mounted behind a Lexan plastic or glass cover in a stainless steel or aluminum frame with a backplate. Install the frame in a conspicuous location observable from each control unit where operations are performed. The card shall show those steps to be taken by an operator when a signal is received under all conditions, normal, alarm, supervisory, and trouble. Provide an

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additional copy with the binder for the input output matrix for the sequence of operation. The instructions shall be approved by the COR before being posted.

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. Installation shall be in accordance with NFPA 70, 72, 90A, and 101 as shown on the drawings, and as recommended by the major equipment manufacturer. Fire alarm wiring shall be installed in conduit. All conduits, junction boxes, conduit supports and hangers shall be concealed in finished areas and may be exposed in unfinished areas.
- B. All new and reused exposed conduits shall be painted in accordance with Section 09 91 00, PAINTING to match surrounding finished areas and red in unfinished areas.
- C. All existing accessible fire alarm conduit not reused shall be removed.
- D. Existing devices that are reused shall be properly mounted and installed. Where devices are installed on existing shallow backboxes, extension rings of the same material, color and texture of the new fire alarm devices shall be used. Mounting surfaces shall be cut and patched in accordance with Section 01 00 00, GENERAL REQUIREMENTS, Restoration, and be re-painted in accordance with Section 09 91 00, PAINTING as necessary to match existing.
- E. All fire detection and alarm system devices shall be flush mounted when located in finished areas and may be surface mounted when located in unfinished areas. Exact locations are to be approved by the COR.
- F. Strobes shall be flush wall mounted with the bottom of the unit located 80 inches (2,000 mm) above the floor or 6 inches (150 mm) below ceiling, whichever is lower. Locate and mount to maintain a minimum 36 inches (900 mm) clearance from side obstructions.
- G. Manual pull stations shall be installed not less than 42 inches (1,050 mm) or more than 48 inches (1,200 mm) from finished floor to bottom of device and within 60 inches (1,500 mm) of a stairway or an exit door.

3.2 TYPICAL OPERATION

- A. Activation of any manual pull station or smoke detector shall cause the following operations to occur:
 - 1. 1. For sprinkler protected buildings, flash strobes continuously only in the zone of alarm. Continuously sound a temporal pattern

- general alarm and flash all strobes in the building in alarm until reset at the local fire alarm control unit in Building 500.
2. Release only the magnetic door holders on the floor from which alarm was initiated after the alert signal.
 3. Transmit a separate alarm signal, via the main fire alarm control unit to the fire department.
 4. Unlock the electrically locked exit doors within the zone of alarm.
- B. Heat detectors in elevator machine rooms shall, in addition to the above functions, disconnect all power to all elevators served by that machine room after a time delay. The time delay shall be programmed within the fire alarm system programming and be equal to the time it takes for the car to travel from the highest to the lowest level, plus 10 seconds.
- C. Smoke detectors in the elevator machine room, or top of hoistway shall, in addition to the above functions, return all elevators in the bank to the primary floor.
- D. Operation of a smoke detector at a corridor door used for automatic closing shall also release only the magnetic door holders on that floor. Operation of a smoke detector at a shutter used for automatic closing shall also release only the shutters on that floor.
- E. Operation of duct smoke detectors shall cause a system supervisory condition and shut down the ventilation system and close the associated smoke dampers as appropriate.
- F. Alarm verification shall not be used for smoke detectors installed for the purpose of early warning.

3.3 TESTS

- A. Provide the service of a NICET level III, competent, factory-trained engineer or technician authorized by the manufacturer of the fire alarm equipment to technically supervise and participate during all of the adjustments and tests for the system. Make all adjustments and tests in the presence of the COR.
- B. When the systems have been completed and prior to the scheduling of the final inspection, furnish testing equipment and perform the following tests in the presence of the COR. When any defects are detected, make repairs or install replacement components, and repeat the tests until such time that the complete fire alarm systems meets all contract

requirements. After the system has passed the initial test and been approved by the COR, the contractor may request a final inspection.

1. Before energizing the cables and wires, check for correct connections and test for short circuits, ground faults, continuity, and insulation.
2. Test the insulation on all installed cable and wiring by standard methods as recommended by the equipment manufacturer.
3. Open each alarm initiating and notification circuit to see if trouble signal actuates.
4. Ground each alarm initiation and notification circuit and verify response of trouble signals.

3.4 FINAL INSPECTION AND ACCEPTANCE

- A. Prior to final acceptance a minimum 30 day "burn-in" period shall be provided. The purpose shall be to allow equipment to stabilize and potential installation and software problems and equipment malfunctions to be identified and corrected. During this diagnostic period, all system operations and malfunctions shall be recorded. Final acceptance will be made upon successful completion of the "burn-in" period and where the last 14 days is without a system or equipment malfunction.
- B. At the final inspection a factory trained representative of the manufacturer of the major equipment shall repeat the tests in Article 3.3 TESTS and those required by NFPA 72. In addition the representative shall demonstrate that the systems function properly in every respect. The demonstration shall be made in the presence of a VA representative.

3.5 INSTRUCTION

- A. The manufacturer's authorized representative shall provide instruction and training to the VA as follows:
 1. Six 1-hour sessions to engineering staff, security police and central attendant personnel 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.

Building 500, AC-19 Replacement
Building 500, AC-20 Replacement
Building 500, Interstitial HVAC Upgrade

Project #613-12-107
Project #613-15-300
Project #613-15-312

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3. Three 8-hour sessions to electrical technicians for maintaining, programming, modifying, and repairing the system at the completion of installation and one 8-hour refresher session 3 months after the completion of installation.
- B. The Contractor and/or the Systems Manufacturer's representative shall provide a typewritten "Sequence of Operation" including a trouble shooting guide of the entire system for submittal to the VA. The sequence of operation will be shown for each input in the system in a matrix format and provided in a loose leaf binder. When reading the sequence of operation, the reader will be able to quickly and easily determine what output will occur upon activation of any input in the system. The INPUT/OUTPUT matrix format shall be as shown in Appendix A to NFPA 72.
- C. Furnish the services of a competent instructor for instructing personnel in the programming requirements necessary for system expansion. Such programming shall include addition or deletion of devices, zones, indicating circuits and printer/display text.

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