100% BID SET

SPECIFICATIONS

VOLUME II
DIV 21 – DIV 23

INSTALL NEW BOILERS, BUILDING 13
Project No. 589A7-18-302

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

07-01-21

DEPARTMENT OF VETERANS AFFAIRS
VHA MASTER SPECIFICATIONS

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SECTION 21 08 00

COMMISSIONING OF FIRE SUPPRESSION SYSTEMS

PART 1 – GENERAL

1.1 DESCRIPTION

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

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

1.2 RELATED WORK

A. Section 01 00 00 GENERAL REQUIREMENTS.

B. Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS.

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

1.3 SUMMARY

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

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

1.4 DEFINITIONS

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

1.5 COMMISSIONED SYSTEMS

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

B. The Fire Suppression systems commissioning will include the systems listed in Section 01 91 00 General Commissioning Requirements:

1.6 SUBMITTALS

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

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

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 CONSTRUCTION INSPECTIONS

A. Commissioning of the building fire suppression systems will require inspection of individual elements of the fire suppression construction throughout the construction period. The Contractor shall coordinate with the Commissioning Agent in accordance with Section 01 91 00 and the Commissioning plan to schedule inspections as required to support the Commissioning Process. Fire suppression system installation, start-up, testing, preparation of O&M Manuals, and training shall be the responsibility of the fire suppression contractors. Oversight of the observation, coordination, verification, and commissioning shall be the responsibility of the CxA. The CxA process does not relive the fire suppression contractors of obligation to complete all portions of the work in a satisfactory manner and ensure systems are fully operational.

3.2 PRE-FUNCTIONAL CHECKLISTS

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

3.3 CONTRACTORS TESTS

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

3.4 SYSTEMS FUNCTIONAL PERFORMANCE TESTING

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

3.5 TRAINING OF VA PERSONNEL

A. Training of the VA operation and maintenance personnel is required in cooperation with the COR and Commissioning Agent. Provide competent, factory authorized personnel to provide instruction to operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. Contractor shall submit training agendas and trainer resumes in accordance with the requirements of Section 01 91 00. The instruction shall be scheduled in coordination with the COR after submission and approval of formal training plans. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS and Division 21 Sections for additional Contractor training requirements.

----- END -----

SECTION 21 13 13
WET-PIPE SPRINKLER SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

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

B. The design and installation of a hydraulically calculated automatic wet-pipe system complete and ready for operation, for all portions of Building 13.

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 22 05 23, GENERAL-DUTY VALVES FOR PLUMBING PIPING.

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

1.3 DESIGN CRITERIA

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

1. Perform hydraulic calculations in accordance with NFPA 13 utilizing the Area/Density method. Do not restrict design area reductions permitted for using quick response sprinklers throughout by the required use of standard response sprinklers in the areas identified in this section.
2. Sprinkler Protection: Sprinkler hazard classifications shall be in accordance with NFPA 13. The hazard classification examples of uses and conditions identified in the Annex of NFPA 13 shall be mandatory for areas not listed below. Request clarification from the Government for any hazard classification not identified. To determining spacing and sizing, apply the following coverage classifications:
   a. Ordinary Hazard Group 2 Occupancies: Boiler Plants
   b. Extra Hazard Group 1 Occupancies: Generator Rooms
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 a flow test of:
   a. Location: Hydrant #15
   b. Static pressure: 75 psi
   c. Residual pressure: 59 psi
   d. Flow: 1,021 gpm
   e. Date: 12/09/2020 Time: 8:00AM
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.
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 and stamped by a NICET Level III or Level IV Sprinkler Technician or a Registered Professional Engineer licensed in the field of Fire Protection Engineering. As the Government and Engineer reviews are for technical adequacy only, the installer remains responsible for correcting any conflicts with other trades and building construction that arise during installation. Partial submittals will not be accepted. Material submittals shall be approved prior to the purchase or delivery to the job site. Suitably bind submittals in notebooks or binders and provide an index referencing the appropriate specification section. In addition to the hard copies, provide submittal items in Paragraphs 1.4(A)1 through 1.4(A)5 electronically in pdf format on a compact disc or as directed by the COR. Submittals shall include, but not be limited to, the following:
   1. Qualifications:
      a. Provide a copy of the installing contractors fire sprinkler and state contractor’s license, as applicable.
      b. Provide a copy of the NICET certification for the NICET Level III or Level IV Sprinkler Technician who prepared and signed the

detailed working drawings unless the drawings are stamped by a Registered Professional Engineer licensed in the field of Fire Protection Engineering.

c. Provide documentation showing that the installer has been actively and successfully engaged in the installation of commercial automatic sprinkler systems for the past ten years.

2. Drawings: Submit detailed 1:100 (1/8 inch) scale (minimum) working drawings conforming to the Plans and Calculations chapter of NFPA 13. Drawings shall include graphical scales that allow the user to determine lengths when the drawings are reduced in size. Include a plan showing the piping to the water supply test location.
3. Manufacturer's Data Sheets: Provide data sheets for all materials and equipment proposed for use on the system. Include listing information and installation instructions in data sheets. Where data sheets describe items in addition to those proposed to be used for the system, clearly identify the proposed items on the sheet.
4. Calculation Sheets:
   a. Submit hydraulic calculation sheets in tabular form conforming to the requirements and recommendations of the Plans and Calculations chapter of NFPA 13.
   b. Submit calculations of loads for sizing of sway bracing in accordance with NFPA 13.
5. Valve Charts: Provide a valve chart that identifies the location of each control valve. Coordinate nomenclature and identification of control valves with COR. Where existing nomenclature does not exist, the chart shall include no less than the following: Tag ID No., Valve Size, Service (control valve, main drain, aux. drain, inspectors test valve, etc.), and Location.
6. Final Document Submittals: Provide as-built drawings, testing and maintenance instructions in accordance with the requirements in Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES. In addition, submittals shall include, but not be limited to, the following:
   a. A complete set of as-built drawings showing the installed system with the specific interconnections between the system switches and the fire alarm equipment. Provide a complete set in the

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

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

b. Material and Testing Certificate: Upon completion of the sprinkler system installation or any partial section of the system, including testing and flushing, provide a copy of a completed Material and Testing Certificate as indicated in NFPA 13. Certificates shall be provided to document all parts of the installation.

c. Operations and Maintenance Manuals that include step-by-step procedures required for system startup, operation, shutdown, and routine maintenance and testing. The manuals shall include the manufacturer's name, model number, parts list, and tools that should be kept in stock by the owner for routine maintenance, including the name of a local supplier, simplified wiring and controls diagrams, troubleshooting guide, and recommended service organization, including address and telephone number, for each item of equipment.

d. One paper copy of the Material and Testing Certificates and the Operations and Maintenance Manuals above shall be provided in a binder. In addition, these materials shall be provided in pdf format on a compact disc or as directed by the COR.

e. Provide one additional copy of the Operations and Maintenance Manual covering the system in a flexible protective cover and mount in an accessible location adjacent to the riser or as directed by the COR.

1.5 QUALITY ASSURANCE

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

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

1.6 APPLICABLE PUBLICATIONS

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

B. National Fire Protection Association (NFPA):

13-19...................Installation of Sprinkler Systems

25-20...................Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems

101-18..................Life Safety Code

170-18..................Fire Safety Symbols

C. Underwriters Laboratories, Inc. (UL):

Fire Protection Equipment Directory (current edition)

D. Factory Mutual Engineering Corporation (FM):

Approval Guide

PART 2 - PRODUCTS

2.1 PIPING & FITTINGS

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

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

B. Piping and fittings for sprinkler systems shall be in accordance with NFPA 13.

1. Plain-end pipe fittings with locking lugs or shear bolts are not permitted.
2. Piping sizes 50 mm (2 inches) and smaller shall be black steel Schedule 40 with threaded end connections.

3. Piping sizes 65 mm (2 ½ inches) and larger shall be black steel Schedule 10 with grooved connections. Grooves in Schedule 10 piping shall be rolled grooved only.
4. 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.
   2. Do not use quarter turn ball valves for 50 mm (2 inch) or larger drain valves.
B. Control Valve: The control valves shall be a listed indicating type. Control valves shall be UL Listed or FM Approved for fire protection installations. System control valve shall be rated for normal system pressure but in no case less than 175 PSI.
C. Check Valve: Shall be of the swing type with a flanged cast iron body and flanged inspection plate.
D. Automatic Ball Drips: Cast brass 20 mm (3/4 inch) in-line automatic ball drip with both ends threaded with iron pipe threads.
E. Backflow Preventer: Provide backflow preventer in accordance with Section 22 05 23, GENERAL-DUTY VALVES FOR PLUMBING PIPING. Provide means to forward flow test the backflow preventer in accordance with NFPA 13.

2.3 FIRE DEPARTMENT SIAMESE CONNECTION

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

2.4 SPRINKLERS

A. All sprinklers shall be FM approved quick response except “institutional” type sprinklers shall be permitted to be UL Listed quick response. Provide FM approved quick response sprinklers in all areas, except that standard response sprinklers shall be provided in freezers, refrigerators, 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.

2.5 SPRINKLER CABINET

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

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

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

2.6 SPRINKLER SYSTEM SIGNAGE

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

2.7 SWITCHES:

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

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

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

2.8 GAUGES

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

2.9 PIPE HANGERS, SUPPORTS AND RESTRAINT OF SYSTEM PIPING

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

2.10 WALL, FLOOR AND CEILING PLATES

A. Provide chrome plated steel escutcheon plates.

2.11 VALVE TAGS

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

PART 3 - EXECUTION

3.1 INSTALLATION

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

B. Installation of Piping: Accurately cut pipe to measurements established by the installer and work into place without springing or forcing. In any situation where bending of the pipe is required, use a standard pipe-bending template. Concealed piping in spaces that have finished ceilings. Where ceiling mounted equipment exists, such as in operating and radiology rooms, install sprinklers so as not to obstruct the movement or operation of the equipment. Sidewall heads may need to be utilized. In stairways, locate piping as near to the ceiling as possible to prevent tampering by unauthorized personnel and to provide a minimum headroom clearance of 2250 mm (seven feet six inches). Piping shall not obstruct the minimum means of egress clearances required by NFPA 101. Pipe hangers, supports, and restraint of system piping, and seismic bracing shall be installed accordance with NFPA 13.

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

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

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

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

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

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

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

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

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

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

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

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

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

P. Painting of Pipe: 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.

Q. Sprinkler System Signage: Provide rigid sprinkler system signage in accordance with NFPA 13 and NFPA 25. Sprinkler system signage shall include, but not limited to, the following:
   1. Identification Signs:
      a. Provide signage for each control valve, drain valve, sprinkler cabinet, and inspector’s test.
      b. Provide valve tags for each operable valve. Coordinate nomenclature and identification of operable valves with COR. Where existing nomenclature does not exist, the Tag Identification shall include no less than the following: (FP-B-F/SZ-#) Fire Protection, Building Number, Floor Number/Smoke Zone (if applicable), and Valve Number. (E.g., FP-500-1E-001) Fire Protection, Building 500, First Floor East, Number 001.)
   2. Instruction/Information Signs:
      a. Provide signage for each control valve to indicate valve function and to indicate what system is being controlled.

b. Provide signage indicating the number and location of low point drains.

3. Hydraulic Placards:

   a. Provide signage indicating hydraulic design information. The placard shall include location of the design area, discharge densities, required flow and residual pressure at the base of riser, occupancy classification, hose stream allowance, flow test information, and installing contractor. Locate hydraulic placard information signs at each alarm check valve.

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

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

T. Coordinate commissioning with the Owner, Commissioning Agent (if applicable), and other trades as necessary. Refer to other specification sections addressing commissioning.

3.2 INSPECTION AND TEST

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

B. Final Inspection and Testing: Subject system to tests in accordance with NFPA 13, and when all necessary corrections have been accomplished, advise COR to schedule a final inspection and test. Connection to the fire alarm system shall have been in service for at least ten days prior to the final inspection, with adjustments made to prevent false alarms. Furnish all instruments, labor and materials required for the tests and provide the services of the installation foreman or other competent representative of the installer to perform the tests. Correct deficiencies and retest system as necessary, prior to the final acceptance. Include the operation of all features of the systems under normal operations in test

3.3 INSTRUCTIONS

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

C. Abbreviations/Acronyms:

1. ABS: Acrylonitrile Butadiene Styrene
2. AC: Alternating Current
3. ACR: Air Conditioning and Refrigeration
4. A/E: Architect/Engineer
5. AFF: Above Finish Floor
6. AFG: Above Finish Grade
7. AI: Analog Input
8. AISI: American Iron and Steel Institute
9. AO: Analog Output
10. ASHRAE: American Society of Heating Refrigeration, Air Conditioning Engineers
11. ASJ: All Service Jacket
12. ASME: American Society of Mechanical Engineers
13. ASPE: American Society of Plumbing Engineers
14. AWG: American Wire Gauge
15. BACnet: Building Automation and Control Network
16. BAg: Silver-Copper-Zinc Brazing Alloy
17. BAS: Building Automation System
18. BCuP: Silver-Copper-Phosphorus Brazing Alloy
19. bhp: Brake Horsepower
20. Btu: British Thermal Unit
21. Btu/h: British Thermal Unit per Hour
22. BSG: Borosilicate Glass Pipe
23. C: Celsius
24. CA: Compressed Air
25. CD: Compact Disk

26. CDA: Copper Development Association
27. CGA: Compressed Gas Association
28. CFM: Cubic Feet per Minute
29. CI: Cast Iron
30. CLR: Color
31. CO: Contracting Officer
32. COR: Contracting Officer’s Representative
33. CPVC: Chlorinated Polyvinyl Chloride
34. CR: Chloroprene
35. CRS: Corrosion Resistant Steel
36. CWP: Cold Working Pressure
37. CxA: Commissioning Agent
38. dB: Decibels
39. db(A): Decibels (A weighted)
40. DCW: Domestic Cold Water
41. DDC: Direct Digital Control
42. DFU: Drainage Fixture Units
43. DHW: Domestic Hot Water
44. DHWR: Domestic Hot Water Return
45. DHWS: Domestic How Water Supply
46. DI: Digital Input
47. DI: Deionized Water
48. DISS: Diameter Index Safety System
49. DN: Diameter Nominal
50. DO: Digital Output
51. DOE: Department of Energy
52. DVD: Digital Video Disc
53. DWG: Drawing
54. DWH: Domestic Water Heater
55. DWS: Domestic Water Supply
56. DWV: Drainage, Waste and Vent
57. ECC: Engineering Control Center
58. EL: Elevation
59. EMCS: Energy Monitoring and Control System
60. EPA: Environmental Protection Agency
61. EPACT: Energy Policy Act
62. EPDM: Ethylene Propylene Diene Monomer
63. EPT: Ethylene Propylene Terpolymer

64. ETO: Ethylene Oxide
65. F: Fahrenheit
66. FAR: Federal Acquisition Regulations
67. FD: Floor Drain
68. FDC: Fire Department (Hose) Connection
69. FED: Federal
70. FG: Fiberglass
71. FNPT: Female National Pipe Thread
72. FOR: Fuel Oil Return
73. FOS: Fuel Oil Supply
74. FOV: Fuel Oil Vent
75. FPM: Fluoroelastomer Polymer
76. FSK: Foil-Scrim-Kraft Facing
77. FSS: VA Construction & Facilities Management, Facility Standards Service
78. FU: Fixture Units
79. GAL: Gallon
80. GCO: Grade Cleanouts
81. GPD: Gallons per Day
82. GPH: Gallons per Hour
83. GPM: Gallons per Minute
84. HDPE: High Density Polyethylene
85. HEFP: Healthcare Environment and Facilities Program (replacement for OCAMES)
86. HEX: Heat Exchanger
87. Hg: Mercury
88. HOA: Hands-Off-Automatic
89. HP: Horsepower
90. HVE: High Volume Evacuation
91. Hz: Hertz
92. ICW: Industrial Cold Water
93. ID: Inside Diameter
94. IE: Invert Elevation
95. INV: Invert
96. IPC: International Plumbing Code
97. IPS: Iron Pipe Size
98. IW: Indirect Waste
99. IWH: Instantaneous Water Heater

100. Kg: Kilogram
101. kPa: Kilopascal
102. KW: Kilowatt
103. KWH: Kilowatt Hour
104. lb: Pound
105. lbs/hr: Pounds per Hour
106. LNG: Liquid Natural Gas
107. L/min: Liters per Minute
108. LOX: Liquid Oxygen
109. L/s: Liters per Second
110. m: Meter
111. MA: Medical Air
112. MAWP: Maximum Allowable Working Pressure
113. MAX: Maximum
114. MBH: 1000 Btu per Hour
115. MED: Medical
116. MER: Mechanical Equipment Room
117. MFG: Manufacturer
118. mg: Milligram
119. mg/L: Milligrams per Liter
120. ml: Milliliter
121. mm: Millimeter
122. MIN: Minimum
123. MV: Medical Vacuum
124. N2: Nitrogen
125. N20: Nitrogen Oxide
126. NC: Normally Closed
127. NF: Oil Free Dry (Nitrogen)
128. NG: Natural Gas
129. NIC: Not in Contract
130. NO: Normally Open
131. NOM: Nominal
132. NPTF: National Pipe Thread Female
133. NPS: Nominal Pipe Size
134. NPT: Nominal Pipe Thread
135. NTS: Not to Scale
136. O2: Oxygen
137. OC: On Center

138. OD: Outside Diameter
139. OSD: Open Sight Drain
140. OS&Y: Outside Stem and Yoke
141. PA: Pascal
142. PBPU: Prefabricated Bedside Patient Units
143. PD: Pressure Drop or Difference
144. PDI: Plumbing and Drainage Institute
145. PH: Power of Hydrogen
146. PID: Proportional-Integral-Differential
147. PLC: Programmable Logic Controllers
148. PP: Polypropylene
149. ppb: Parts per Billion
150. ppm: Parts per Million
151. PSI: Pounds per Square Inch
152. PSIA: Pounds per Square Inch Atmosphere
153. PSIG: Pounds per Square Inch Gauge
154. PTFE: Polytetrafluoroethylene
155. PVC: Polyvinyl Chloride
156. PVDF: Polyvinylidene Fluoride
157. RAD: Radians
158. RO: Reverse Osmosis
159. RPM: Revolutions Per Minute
160. RTD: Resistance Temperature Detectors
161. RTRP: Reinforced Thermosetting Resin Pipe
162. SAN: Sanitary Sewer
163. SCFM: Standard Cubic Feet per Minute
164. SDI: Silt Density Index
165. SMACNA: Sheet Metal and Air Conditioning Contractors National Association
166. SPEC: Specification
167. SPS: Sterile Processing Services
168. SQFT/SF: Square Feet
169. SS: Stainless Steel
170. STD: Standard
171. SUS: Saybolt Universal Second
172. SWP: Steam Working Pressure
173. TD: Temperature Difference
174. TDH: Total Dynamic Head

175. TEFC: Totally Enclosed Fan-Cooled
176. TEMP: Temperature
177. TFE: Tetrafluoroethylene
178. THERM: 100,000 Btu
179. THHN: Thermoplastic High-Heat Resistant Nylon Coated Wire
180. THWN: Thermoplastic Heat & Water-Resistant Nylon Coated Wire
181. TIL: Technical Information Library http//www.cfm.va.gov/til/indes.asp
182. T/P: Temperature and Pressure
183. TYP: Typical
184. USDA: U.S. Department of Agriculture
185. V: Vent
186. V: Volt
187. VA: Veterans Administration
188. VA CFM: VA Construction & Facilities Management
189. VA CFM CSS: VA Construction & Facilities Management, Consulting Support Service
190. VAC: Vacuum
191. VAC: Voltage in Alternating Current
192. VAMC: Veterans Administration Medical Center
193. VHA OCAMES: This has been replaced by HEFP.
194. VSD: Variable Speed Drive
195. VTR: Vent through Roof
196. W: Waste
197. WAGD: Waste Anesthesia Gas Disposal
198. WC: Water Closet
199. WG: Water Gauge
200. WOG: Water, Oil, Gas
201. WPD: Water Pressure Drop
202. WSFU: Water Supply Fixture Units

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.
B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
C. Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT.
D. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.
E. Section 02 82 11, TRADITIONAL ASBESTOS ABATEMENT.
F. Section 03 30 00, CAST-IN-PLACE CONCRETE: Concrete and Grout.

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

H. Section 05 50 00, METAL FABRICATIONS.

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

J. Section 07 84 00, FIRESTOPPING.

K. Section 07 92 00, JOINT SEALANTS.

L. Section 09 91 00, PAINTING.

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

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

O. Section 22 07 11, PLUMBING INSULATION.

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

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

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

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

T. Section 26 29 11, MOTOR CONTROLLERS.

U. Section 31 20 00, EARTH MOVING: Excavation and Backfill.

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. Where conflicts occur these specifications and the VHA standard will govern.

B. American Society of Mechanical Engineers (ASME):

ASME Boiler and Pressure Vessel Code -

BPVC Section IX-2019.... Welding, Brazing, and Fusing Qualifications

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

A36/A36M-2019...........Standard Specification for Carbon Structural Steel

A575-96(2013)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-2018................International Building Code

IPC-2018................International Plumbing Code

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

SP-58-2018..............Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application and Installation

F. Military Specifications (MIL):

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

G. National Electrical Manufacturers Association (NEMA):

MG 1-2016...............Motors and Generators

H. National Fire Protection Association (NFPA):

51B-2019................Standard for Fire Prevention During Welding, Cutting and Other Hot Work

54-2018.................National Fuel Gas Code

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

99-2018.................Healthcare Facilities Code

I. NSF International (NSF):

5-2019..................Water Heaters, Hot Water Supply Boilers, and Heat Recovery Equipment

14-2019.................Plastic Piping System Components and Related Materials

61-2019.................Drinking Water System Components – Health Effects

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

J. Department of Veterans Affairs (VA):

PG-18-102014(R18).......Plumbing Design Manual

PG-18-13-2017(R18)......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. If the project is phased, contractors shall submit complete phasing plan/schedule with manpower levels prior to commencing work. The phasing plan shall be detailed enough to provide milestones in the process that can be verified.

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

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

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

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

H. Manufacturer's Literature and Data including: Manufacturer’s literature shall be submitted under the pertinent section rather than under this section.

   1. Electric motor data and variable speed drive data shall be submitted with the driven equipment.

2. Equipment and materials identification.
3. Firestopping materials.
4. Hangers, inserts, supports and bracing. Provide load calculations for variable spring and constant support hangers.
5. Wall, floor, and ceiling plates.

I. Coordination/Shop Drawings:

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

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

K. Plumbing Maintenance Data and Operating Instructions:

1. Maintenance and operating manuals in accordance with Section 01 00 00, GENERAL REQUIREMENTS, Article, INSTRUCTIONS, for systems and equipment.

2. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replacement parts, and troubleshooting guide:
   a. Include complete list indicating all components of the systems.
   b. Include complete diagrams of the internal wiring for each item of equipment.
   c. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.
3. Provide a listing of recommended replacement parts for keeping in stock supply, including sources of supply, for equipment. Include in the listing belts for equipment: Belt manufacturer, model number, size and style, and distinguished whether of multiple belt sets.

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

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

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

1.5 QUALITY ASSURANCE

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

B. 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.

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 4 hours of receipt of notification by phone, e-mail or fax in event of an emergency, such as the shut-down of equipment; or within 24 hours in a non-emergency. Names, mail and e-mail addresses and phone numbers of service organizations providing service under these conditions for (as applicable to the project): pumps, compressors, water heaters, critical instrumentation, computer workstation and programming 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 the attention of the Contracting Officers Representative (COR).
5. Multiple Units: When two or more units of materials or equipment of the same type or class are required, these units shall be of the same manufacturer and model number, or if different models are required they shall be of the same manufacturer and identical to the greatest extent possible (i.e., same model series).
6. Assembled Units: Performance and warranty of all components that make up an assembled unit shall be the responsibility of the manufacturer of the completed assembly.
7. Nameplates: Nameplate bearing manufacturer's name or identifiable trademark shall be securely affixed in a conspicuous place on equipment, or name or trademark cast integrally with equipment, stamped or otherwise permanently marked on each item of equipment.
8. Asbestos products or equipment or materials containing asbestos is prohibited.

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

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

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

E. Execution (Installation, Construction) Quality:
   1. All items shall be applied and installed in accordance with 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.
   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. Failure of the Contractor to resolve or call attention to any discrepancies or deficiencies to the COR will result in the Contractor correcting at no additional cost or time to the Government.

3. 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. Workmanship/craftsmanship will be of the highest quality and standards. The VA reserves the right to reject any work based on poor quality of workmanship this work shall be removed and done again at no additional cost or time to the Government.

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

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

H. Plumbing Systems: IPC, International Plumbing Code. Unless otherwise required herein, perform plumbing work in accordance with the latest version of the IPC. For IPC codes referenced in the contract documents, advisory provisions 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.

I. 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

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

1.7 AS-BUILT DOCUMENTATION

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

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

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

  1. As-built drawings are to be provided, with a copy of them on AutoCAD provided on CD or DVD. The CAD drawings shall use multiple line layers with a separate individual layer for each system.

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

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

1.8 JOB CONDITIONS – WORK IN EXISTING BUILDING

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

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

C. Steam and Condensate Service Interruptions: Limited steam and condensate service interruptions, as required for interconnections of new and existing systems, will be permitted by the COR during periods when the demands are not critical to the operation of the VAMC. These non-critical periods are limited to between 8 pm and 5 am in the appropriate off-season (if applicable). Provide at least 10 working days advance notice to the COR. The request shall include a detailed plan on the proposed shutdown and the intended work to be done along with manpower levels. All equipment and materials must be onsite and verified with plan 5 work days prior to the shutdown or it will need to be rescheduled.

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

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

F. Acceptance of Work for Government Operation: As new equipment, systems and facilities are made available for operation and these items are deemed of beneficial use to the Government, inspections 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 Paragraph, TEMPORARY PIPING AND EQUIPMENT in this section.

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 drinking fountains, lavatory faucets, kitchen and bar faucets, ice makers supply stops, and 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.
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-gauge 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.

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 at no 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.

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” and the requirements generally exceed those of the Energy Policy Act (EPACT), revised 2005. Motors not specified as “high efficiency or premium efficient” shall comply with EPACT.

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

B. Interior (Indoor) Equipment: Engraved nameplates, with letters not less than 7 mm (3/16 inch) high of brass with black-filled letters, or rigid black plastic with white letters specified in Section 09 91 00, PAINTING shall be permanently fastened to the equipment. Unit components such as water heaters, tanks, coils, filters, etc. shall be identified.

C. Exterior (Outdoor) Equipment: Brass nameplates, with engraved black filled letters, not less than 7 mm (3/16 inch) high riveted or bolted to the equipment.

D. 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.

E. Valve Tags and Lists:

1. Plumbing: All valves shall be provided with valve tags and listed on a valve list (Fixture stops not included).
2. Valve tags: Engraved black filled numbers and letters not less than 15 mm (1/2 inch) high for number designation, and not less than 8 mm (1/4 inch) for service designation on 19-gauge, 40 mm (1-1/2 inches) round brass disc, attached with brass "S" hook or brass chain.
3. Valve lists: Valve lists 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) and Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS. Submittals based on the International Building Code (IBC) and Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS requirements, or the following paragraphs of this Section shall be stamped and signed by a 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. 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. Attachment to Metal Pan or Deck: As required for materials specified in Section 05 31 00, STEEL DECKING. Section 05 36 00, COMPOSITE METAL DECKING.

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

G. 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.

H. Multiple (Trapeze) Hangers: Galvanized, cold formed, lipped steel channel horizontal member, not less than 43 mm by 43 mm (1-5/8 inches by 1-5/8 inches), 2.7 mm (No. 12 gauge), designed to accept special spring held, hardened steel nuts.

   1. Allowable hanger load: Manufacturers rating less 91kg (200 pounds).
   2. Guide individual pipes on the horizontal member of every other trapeze hanger with 8 mm (1/4 inch) U-bolt fabricated from steel rod. Provide Type 40 insulation shield, secured by two 15 mm (1/2 inch) galvanized steel bands, or insulated calcium silicate shield for insulated piping at each hanger.

I. 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.
   c. Hangers and supports in pipe chase: Prefabricated system ABS self-extinguishing material, not subject to electrolytic action, to hold piping, prevent vibration and compensate for all static and operational conditions.
   d. Blocking, stays and bracing: Angle iron or preformed metal channel shapes, 1.3 mm (18 gauge) minimum.

J. Pre-insulated Calcium Silicate Shields:
   1. Provide 360-degree water resistant high density 965 kPa (140 psig) compressive strength calcium silicate shields encased in galvanized metal.
   2. Pre-insulated calcium silicate shields to be installed at the point of support during erection.
   3. Shield thickness shall match the pipe insulation.
   4. The type of shield is selected by the temperature of the pipe, the load it must carry, and the type of support it will be used with.
      a. Shields for supporting cold water shall have insulation that extends a minimum of 25 mm (1 inch) past the sheet metal.
      b. The insulated calcium silicate shield shall support the maximum allowable water filled span as indicated in MSS SP-58. To support the load, the shields shall have one or more of the following features: structural inserts 4138 kPa (600 psig) compressive strength, an extra bottom metal shield, or formed structural steel (ASTM A36/A36M) wear plates welded to the bottom sheet metal jacket.
   5. Shields may be used on steel clevis hanger type supports, trapeze hangers, roller supports or flat surfaces.

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

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

D. Penetrations are prohibited through beams or ribs, but may be installed in concrete beam flanges, with structural engineer prior approval. Any deviation from these requirements must receive prior approval of COR.

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

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

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

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

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

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

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

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

2.14 ASBESTOS

A. Materials containing asbestos are prohibited.

PART 3 - EXECUTION

3.1 ARRANGEMENT AND INSTALLATION OF EQUIPMENT AND PIPING

A. Location of piping, sleeves, inserts, hangers, and equipment, access provisions 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 gauges 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 in 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.
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. Minor Piping: Generally, small diameter pipe runs from drips and drains, water cooling, and other services are not shown but must be provided.

H. Protection and Cleaning:

1. Equipment and materials 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.

I. Concrete and Grout: Concrete and shrink compensating grout 25 MPa (3000 psig) minimum, specified in Section 03 30 00, CAST-IN-PLACE CONCRETE, shall be used for all pad or floor mounted equipment.

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

K. Interconnection of Controls and Instruments: 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.

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

M. Work in Existing Building:

1. Perform as specified in Article, OPERATIONS AND STORAGE AREAS, Article, ALTERATIONS, and Article, RESTORATION of the Section 01 00

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

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

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

O. 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.

P. 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.

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 pipeline and any openings in structures sealed. Dead legs are prohibited 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.

3.4 PIPE AND EQUIPMENT SUPPORTS

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

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

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

D. For horizontal and vertical plumbing pipe supports, refer to the International Plumbing Code (IPC) 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.
3. All equipment shall be shimmed, leveled, firmly anchored, and grouted with epoxy grout. Anchor bolts shall be placed in sleeves, anchored to the bases. Fill the annular space between sleeves and bolts with a grout material to permit alignment and realignment.
4. For seismic anchoring, refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

3.5 LUBRICATION

A. All equipment and devices requiring lubrication shall be lubricated prior to initial operation. All devices and equipment shall be field checked for proper lubrication.

B. All devices and equipment shall be equipped with required lubrication fittings. A minimum of 1 liter (1 quart) of oil and 0.45 kg (1 pound) of grease of manufacturer's recommended grade and type for each different application 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 in the drawings, shall be provided after approval for structural integrity by the COR. Such access shall be provided at no 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 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 VAMC, 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 gauges and thermometers with wells shall remain Government property and shall be removed and delivered to COR and stored as directed. The Contractor shall remove all other material and equipment, devices and demolition debris under these 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.

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 gauges 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 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.
B. The CxA will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the Contracting Officer’s Representative and CxA. Provide a minimum of four (4) weeks prior notice.

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.

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 4 hours to instruct each VA personnel responsible in operation and maintenance of the system.

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

- - - E N D - - -

09-01-20

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 common acronyms and abbreviations are included in Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

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

C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

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

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

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

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

H. Section 26 24 19, MOTOR-CONTROL CENTERS: Motor Control Centers.

I. 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. Where conflicts occur these specifications and VHA standard will govern.

B. American Bearing Manufacturers Association (ABMA):

ABMA 9–2015.............Load Ratings and Fatigue Life for Ball Bearings

C. Institute of Electrical and Electronics Engineers, Inc. (IEEE):

112-2017................IEEE Standard Test Procedure for Polyphase Induction Motors and Generators

841-2018................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-2018................International Plumbing Code

E. National Electrical Manufacturers Association (NEMA):

MG 1-2016...............Motors and Generators

MG 2-2014...............Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators

250-2018................Enclosures for Electrical Equipment (1000 Volts Maximum)

F. National Fire Protection Association (NFPA):

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

1.4 SUBMITTALS

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

B. Information and material submitted under this section shall be marked “SUBMITTED UNDER SECTION 22 05 12, GENERAL MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT”, with applicable paragraph identification.

C. Submit motor submittals with drive equipment.

D. Shop Drawings:

1. Provide documentation to demonstrate compliance with contract documents.
2. Motor nameplate information shall be submitted including electrical ratings, efficiency, bearing data, power factor, frame size, dimensions, mounting details, materials, horsepower, voltage, phase, speed (RPM), enclosure, starting characteristics, torque characteristics, code letter, full load and locked rotor current, service factor, and lubrication method.
3. Motor parameters required for the determination of the Reed Critical Frequency of vertical hollow shaft motors shall be submitted.

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

F. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replaceable parts and troubleshooting guide:

1. Include complete list indicating all components of the systems.
2. Include complete diagrams of the internal wiring for each item of equipment.
3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

G. 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.
H. Completed System Readiness Checklist provided by the CxA and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.
I. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

1.5 QUALITY ASSURANCE

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

1.6 AS-BUILT DOCUMENTATION

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

PART 2 - PRODUCTS

2.1 MOTORS

A. All material and equipment furnished, and installation methods shall conform to the requirements of Section 26 29 11, MOTOR CONTROLLERS; and Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES. Provide all electrical wiring, conduit, and devices necessary for the proper connection, protection and operation of the systems. Provide premium efficiency type motors. Unless otherwise specified for a particular application, use electric motors with the following requirements.
B. For alternating current, fractional and integral horsepower motors, NEMA MG 1 and NEMA MG 2 shall apply.
C. For severe duty totally enclosed motors, IEEE 841 shall apply. For severe duty totally enclosed motors, IEEE 841 shall apply.

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

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

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

F. Voltage ratings shall be as follows:

   1. Single phase:

      a. Motors connected to 120-volt systems: 115 volts.

      b. Motors connected to 208-volt systems: 200 volts.

      c. Motors connected to 240-volt or 480-volt systems: 230/460 volts, dual connection.

   2. Three phase:

      a. Motors connected to 208-volt systems: 200 volts.

      b. Motors, less than 74.6 kW (100 HP), connected to 240-volt or 480-volt systems: 230/460 volts, dual connection.

      c. Motors, 74.6 kW (100 HP) or greater, connected to 240-volt systems: 230 volts.

      d. Motors, 74.6 kW (100 HP) or greater, connected to 480-volt systems: 460 volts.

      e. Motors connected to high voltage systems (Over 600V): Shall conform to NEMA MG 1 for connection to the nominal system voltage shown in the drawings.

G. Number of phases shall be as follows:

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

   2. Motors, 373 W (1/2 HP) and greater: 3 phase.

   3. Exceptions:

      a. Hermetically sealed motors.

      b. Motors for equipment assemblies, less than 746 W (1 HP), may be single phase provided the manufacturer of the proposed assemblies cannot supply the assemblies with three phase motors.

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

I. Motor designs, as indicated by the NEMA code letters, shall be coordinated with the connected loads to assure adequate starting, acceleration and running torque without exceeding nameplate ratings or considering service factor.

J. Motor Enclosures:

1. Shall be the NEMA types as specified and/or shown in the Contract Documents.
2. Where the types of motor enclosures are not shown in the drawings, they shall be the NEMA types per NEMA 250, which are most suitable for the environmental conditions where the motors are being installed. Enclosure requirements for certain conditions are as follows:
    a. Motors located outdoors, indoors in wet or high humidity locations, or in unfiltered airstreams shall be totally enclosed type.
    b. Where motors are located in an NEC 511 classified area, provide TEFC explosion proof motor enclosures.
    c. Where motors are located in a corrosive environment, provide TEFC enclosures with corrosion resistant finish.
3. Enclosures shall be primed and finish coated at the factory with manufacturer's prime coat and standard finish.

K. Electrical Design Requirements:

1. Motors shall be continuous duty.
2. The insulation system shall be rated minimum of Class B, 130 degrees C (266 degrees F).
3. The maximum temperature rise by resistance at rated power shall not exceed Class B limits, 80 degrees C (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.
6. Motors for variable frequency drive applications shall adhere to NEMA MG 1, Part 30, Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable Voltage or Adjustable Frequency Controls, or both, or NEMA MG 1, Part 31, Definite Purpose Inverter Fed Polyphase Motors.

L. Mechanical Design Requirements:

1. Bearings shall be rated for a minimum fatigue life of 26,280 hours for belt-driven loads and 100,000 hours for direct-drive loads based on L10 (Basic Rating Life) at full load direct coupled, except vertical high thrust motors which require a 40,000 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. Vibration shall not exceed 3.8 mm (0.15 inch) per second, unfiltered peak.
4. Noise level shall meet the requirements of the application.
5. Motors on 180 frames and larger shall have provisions for lifting eyes or lugs capable of a safety factor of 5.
6. All external fasteners shall be corrosion resistant.
7. Grounding provisions shall be in the main terminal box.

M. Special Requirements:

1. Where motor power requirements of equipment furnished deviate from power shown on plans, provide electrical service designed under the requirements of NFPA 70 without additional cost or time to the Government.
2. Assemblies of motors, starters, controls and interlocks on factory assembled and wired devices shall be in accordance with the requirements of this specification.
3. Wire and cable materials specified in the electrical division of the specifications shall be modified as follows:
   a. Wiring material located where temperatures can exceed 71 degrees C (160 degrees F) shall be stranded copper with Teflon FEP insulation with jacket. This includes wiring on the boilers.
   b. Other wiring at boilers and to control panels shall be NFPA 70 designation THWN.
   c. Provide shielded conductors or wiring in separate conduits for all instrumentation and control systems where recommended by manufacturer of equipment.
4. Select motor sizes so that the motors do not operate into the service factor at maximum required loads on the driven equipment. Motors on pumps shall be sized for non-overloading at all points on the pump performance curves.

5. Motors utilized with variable frequency drives shall be rated “inverter-duty” per NEMA MG 1, Part 31, Definite-Purpose Inverter-Fed Polyphase Motors. Provide motor shaft grounding apparatus that will protect bearings from damage from stray currents.

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

O. Minimum Power Factor at Full Load and Rated Voltage: 90 percent at 1200 RPM, 1800 RPM and 3600 RPM. Power factor correction capacitors shall be provided unless the motor meets the 0.9 requirement without it or if the motor is controlled by a variable frequency drive. The power factor correction capacitors shall be able to withstand high voltage transients and power line variations without breakdown.

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

Polyphase Open Motors Average full load efficiency				**Capacitor-start capacitor-run and capacitor-start induction run open motors Average full load efficiency**			
Rating kW (hp)	**6 poles**	**4 poles**	**2 poles**	**Rating kW (hp)**	**6 poles**	**4 poles**	**2 poles**
0.18 (0.25)	67.5	69.5	65.6	0.18 (0.25)	62.2	68.5	66.6
0.25 (0.33)	71.4	73.4	69.5	0.25 (0.33)	66.6	72.4	70.5
0.37 (0.5)	75.3	78.2	73.4	0.37 (0.5)	76.2	76.2	72.4
0.55 (0.75)	81.7	81.1	76.8	0.55 (0.75)	80.2	81.8	76.2

PART 3 - EXECUTION

3.1 INSTALLATION

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

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

3.2 FIELD TESTS

A. All tests shall be witnessed by the CxA or by the COR.

B. Perform an electric insulation resistance Test using a megohmmeter on all motors after installation, before startup. All shall test free from grounds.

C. Perform Load test in accordance with IEEE 112, Test Method B, to determine freedom from electrical or mechanical defects and compliance with performance data.

D. Insulation Resistance: Not less than 1/2 meg-ohm between stator conductors and frame, to be determined at the time of final inspection.

E. All test data shall be complied into a report form for each motor and provided to the contracting officer or their representative.

3.3 STARTUP AND TESTING

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

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

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

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 shall be tested as part of a larger system.

3.5 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer’s technical representative for 4 hours to instruct each VA personnel responsible in operation and maintenance of the system.

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

- - - E N D - - -

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 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. American Water Works Association (AWWA):

C700-2009...............Standard for Cold Water Meters, Displacement Type, Bronze Main Case

C701-2012...............Cold Water Meters-Turbine Type, for Customer Service

C702-2010...............Cold Water Meters – Compound Type

C706-2010...............Direct-Reading, Remote-Registration Systems for Cold-Water Meters

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

C2–2012.................National Electrical Safety Code (NESC)

E. International Code Council (ICC):

IPC-2012................International Plumbing Code

F. National Fire Protection Association (NFPA):

70–2011.................National Electrical Code (NEC)

G. NSF International (NSF):

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

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

1.4 SUBMITTALS

A. Submittal 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 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. Water Meter.
2. Pressure Gages.
3. Thermometers.
4. Product certificates for each type of meter and gage.
5. BACnet communication protocol.

D. Operations and Maintenance manual shall include:

1. System Description.
2. Major assembly block diagrams.
3. Troubleshooting and preventive maintenance guidelines.
4. Spare parts information.

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

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, 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. 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 TURBINE WATER METER

A. The water meter shall be Turbine type, Class II, in-line, horizontal axis, and fully conform to AWWA C701. Peak domestic flow shall be as indicated on drawings. The meter Register shall indicate flow in liters (U.S. gallons).

B. The water meter shall be rated for use at temperatures ranging from -40 degrees C (-40 degrees F) and 70 degrees C (158 degrees F) and operate at a working pressure of 1035 kPa (150 psig).

C. The turbine case shall be constructed of leadfree alloy cast bronze or epoxy-coated cast iron.

D. The register box rings and lid shall be made of cast copper alloy containing not less than 75 percent copper. Forged or die cast copper alloy containing not less than 75 percent copper or a suitable synthetic polymer.

E. The flow measuring turbine shall be made of a suitable synthetic polymer with specific gravity approximately equal to that of water. The measuring turbine shall have sufficient dimensional stability to retain operating clearances at the full range of working temperatures.

F. All external case closures, such as rings, clamps, screws, bolts, cap bolts, nuts and washers shall be designed for easy removal following lengthy service.

G. The turbine meter shall have flanged ends and supplied with companion flanges, gaskets, and with bolts and nuts. The companion flanges shall be made of cast iron.

H. The meter shall register plus or minus 3 percent of the water actually passing through it at any rate of flow within the normal test flow limits specified in AWWA 701.

I. The water meter shall conform to NSF 61 and NSF 372.

2.2 WATER METER STRAINER

A. All meters shall be fitted with a factory installed integral strainer or bronze inlet strainer with top access. The strainer shall conform to AWWA C702.

B. The water meter strainer shall conform to NSF 61 and NSF 372.

2.3 WATER METER PROGRAMMING

A. All meters 50 mm or DN 50 (2 inches) and above shall be programmable with software supplied by the meter manufacturer.

B. The software shall have a Microsoft based interface and operate on the latest Windows operating system. The software shall allow the user to configure the meter, troubleshoot the meter, query and display meter parameters, and configure data and stored values.

C. The meter firmware shall be upgradeable through one of the communication ports without removing the unit from service.

D. The meter shall include output for analog 4-20 milliamp signals and binary output.

E. The meter shall have two dry contact relays outputs for alarm or control functions.

2.4 WATER METER COMMUNICATION PROTOCOL

A. The meter shall use a native BACnet Ethernet communication protocol supporting HTTP or Modbus. The communications shall be protected against surges induced on its communications channels.

2.5 REMOTE READOUT REGISTER

A. All meters shall be equipped with a remote readout register in accordance with AWWA C706.

2.6 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.

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.

2.7 THERMOMETERS

A. Thermometers shall be straight stem, metal case, red liquid-filled thermometer, approximately 175 mm (7 inches) high, 4 degrees C to 100 degrees C (40 degrees F to 212 degrees 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. Building water service entrance into building.
2. Suction and discharge of each domestic water pump or re-circulating hot water return pump.

E. Water meter installation shall conform to AWWA C700, AWWA C701, and AWWA C702. Electrical installations shall conform to IEEE C2, NFPA 70, and to the requirements specified herein. New materials shall be provided.

F. Remote readout register shall be mounted at the location indicated on the drawings or as directed by the COR.

G. 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.

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

3.2 FIELD QUALITY CONTROL

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

3.3 TRAINING

A. A training course shall be provided to the medical center on meter configuration and maintenance. Training manuals shall be supplied for all attendees with four additional copies supplied. The training course shall cover meter configuration, troubleshooting, and diagnostic procedures.

- - - E N D - - -

SECTION 22 05 23
GENERAL-DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

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

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

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

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

C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

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

E. 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. Where conflicts occur these specifications and the VHA standard will govern.

B. American Society of Sanitary Engineering (ASSE):

1001-2017...............Performance Requirements for Atmospheric Type Vacuum Breakers

1011-2017...............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

1035-2008...............Performance Requirements for Laboratory Faucet Backflow Preventers

1069-2005...............Performance Requirements for Automatic Temperature Control Mixing Valves

1070-2015...............Performance Requirements for Water Temperature Limiting Devices

1071-2012...............Performance Requirements for Temperature Actuated Mixing Valves for Plumbed Emergency Equipment

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

A276/A276M-2017.........Standard Specification for Stainless Steel Bars and Shapes

A536-1984(R2019e).......Standard Specification for Ductile Iron Castings

B62-2017................Standard Specification for Composition Bronze or Ounce Metal Castings

B584-2014...............Standard Specification for Copper Alloy Sand Castings for General Applications

D. International Code Council (ICC):

IPC-2018................International Plumbing Code

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

SP-25-2018..............Standard Marking Systems for Valves, Fittings, Flanges and Unions

SP-67-2017..............Butterfly Valves

SP-80-2019..............Bronze Gate, Globe, Angle, and Check Valves

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

F. NSF International (NSF):

61-2019.................Drinking Water System Components – Health Effects

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

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

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

1.4 SUBMITTALS

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

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

C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.
   1. Ball Valves.
   2. Gate Valves.
   3. Butterfly Valves.
   4. Balancing Valves.
   5. Check Valves.
   6. Backflow Preventers.
   7. Thermostatic Mixing Valves.

D. Test and Balance reports for balancing valves.

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

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

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

1.5 DELIVERY, STORAGE, AND HANDLING

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

6. Block check valves in either closed or open position.

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

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

1.6 AS BUILT DOCUMENTATION

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

PART 2 - PRODUCTS

2.1 VALVES, GENERAL

A. Asbestos packing and gaskets are prohibited.

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

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

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

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

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

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

2.2 SHUT-OFF VALVES

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

1. 50 mm or DN50 (2 inches) and smaller: Ball, MSS SP-110, Ball valve shall be full port three piece or two piece with a union design with adjustable stem package. Threaded stem designs are not allowed. The ball valve shall have a SWP rating of 1035 kPa (150 psig) and a CWP rating of 4138 kPa (600 psig). The body material shall be Bronze ASTM B584, 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 greater:

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

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

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

2.3 MANUAL BALANCING VALVES

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

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

2.4 THERMOSTATIC BALANCING VALVES

A. Thermostatic recirculation balancing valves for domestic hot water and domestic cold water application. Thermostatically controlled, spring actuated automatic balancing valve to very recirculation flow to maintain constant return temperatures. Stainless steel body, spring and brass or stainless steel thermal actuator and actuator carrier. Provide with threaded inlet, integral outlet union and stainless steel check valve. Direct acting to maintain return hot water temperature at 43 degrees C (110 degrees F). PTFE seat seal ring and EPDM body seal.

2.5 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.

2.6 WATER PRESSURE REDUCING VALVE AND CONNECTIONS

A. 75 mm or DN75 (3 inches) or smaller: The pressure reducing valve shall consist of a bronze body and bell housing, a separate access cover for the plunger, and a bolt to adjust the downstream pressure. The pressure reducing valve shall meet ASSE 1003. The bronze bell housing and access cap shall be threaded to the body and shall not require the use of ferrous screws. The assembly shall be of the balanced piston design and shall reduce pressure in both flow and no flow conditions. The assembly shall be accessible for maintenance without having to remove the body from the line.

2.7 BACKFLOW PREVENTERS

A. A backflow prevention assembly shall be installed at any point in the plumbing system where the potable water supply comes in contact with a potential source of contamination. The backflow prevention assembly shall be approved by the University of Southern California Foundation for Cross Connection Control and Hydraulic Research (USCFCCC).

B. The reduced pressure principle backflow prevention assembly shall be ASSE listed 1013 with full port OS&Y positive-seal resilient gate valves and an integral relief monitor switch. The main body and access cover shall be epoxy coated ductile iron conforming to ASTM A536 grade 4. The seat ring and check valve shall be the thermoplastic type suited for water service. The stem shall be stainless steel conforming to ASTM A276/A276M. The seat disc shall be the elastomer type suited for water service. The checks and the relief valve shall be accessible for maintenance without removing the device from the line. An epoxy coated wye type strainer with flanged connections shall be installed on the inlet. Reduced pressure backflow preventers shall be installed in the following applications.

   1. Deionizers.
   2. Water make up to heating systems, cooling tower, chilled water system, generators, and similar equipment consuming water.
   3. Water service entrance from loop system.
   4. Process equipment.

C. The pipe applied or integral atmospheric vacuum breaker shall be ASSE listed 1001. The main body shall be cast bronze. The seat disc shall be the elastomer type suited for water service. The device shall be accessible for maintenance without removing the device from the service line. The installation shall not be in a concealed or inaccessible location or where the venting of water from the device during normal operation is deemed objectionable. Atmospheric vacuum breakers shall be installed in the following applications.

1. Hose bibs and sinks with threaded outlets.
2. Showers (telephone/handheld type).
3. Service sinks (integral with faucet only).
4. Laundry tubs (integral with faucet only).

D. The hose connection vacuum breaker shall be ASSE listed 1011. The main body shall be cast brass with stainless steel working parts. The diaphragm and disc shall be the elastomer type suited for water service. The device shall permit the attachment of portable hoses to hose thread outlets. Hose connection vacuum breakers shall be installed in the following locations requiring non-continuous pressure:

1. Hose bibbs and wall hydrants.

E. The pressure vacuum breaker shall be ASSE listed 1020. The main body shall be brass. The disc and O-ring seal shall be the elastomer type. The valve seat and disc float shall be the thermoplastic type. Tee handle or lever handle shut-off ball valves. Test cocks for testing and draining where freezing conditions occur. All materials shall be suitable for water service. The device shall be accessible for maintenance without removing the device from the service line. The installation shall not be in a concealed or inaccessible location or where the venting of water from the device during normal operation is deemed objectionable. Pressure vacuum breakers shall be installed in the following locations requiring continuous pressure and no backpressure including equipment with submerged inlet connections:

1. 1. Lawn Irrigation.

2.8 THERMOSTATIC MIXING VALVES

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

1. Shall meet ASSE requirements for water temperature control.
2. The body shall be cast bronze or brass with corrosion resistant internal parts preventing scale and biofilm build-up. Provide chrome-plated finish in exposed areas.
3. No special tool shall be required for temperature adjustment, maintenance, replacing parts and disinfecting operations.

4. Valve shall be able to be placed in various positions without making temperature adjustment or reading difficult.
5. Valve finish shall be chrome plated in exposed areas.
6. Valve shall allow easy temperature adjustments to allow hot water circulation. Internal parts shall be able to withstand disinfecting operations of chemical and thermal treatment of water temperatures up to 82°C (180°F) for 30 minutes or 50 mg/L (50 ppm) chlorine residual concentration for 24 hours.
7. Parts shall be easily removed or replaced without dismantling the valves, for easy scale removal and disinfecting of parts.
8. Valve shall have a manual adjustable temperature control with locking mechanism to prevent tampering by end user. Outlet temperature shall be visible to ensure outlet temperature does not exceed specified limits, particularly after thermal eradication procedures.

B. Master Thermostatic Water Mixing Valves:
1. Application: Tempered water distribution from hot water source.
2. Standard: ASSE 1017.
3. Pressure Rating: 861 kPa (125 psig).
4. Type: Exposed-mounting or Cabinet-type, as indicated, thermostatically controlled water mixing valve.
5. Connections: Flanged or threaded union inlets and outlet.
6. Thermometers shall be provided to indicate mixed water temperature.

C. Automatic Water Temperature Control Mixing Valves:
1. Application: Gang plumbing fixtures point-of-use when no other mixing at fixtures occurs.
2. Standard: ASSE 1069.
3. Pressure Rating: 861 kPa (125 psig).
4. Type: Thermostatically controlled water mixing valve set at 43 degrees C (110 degrees F).
5. Connections: Threaded union or soldered inlets and outlet.
6. Thermometers shall be provided to indicate mixed water temperature.
7. Upon cold water supply failure, the hot water flow shall automatically be reduced to 0.5 gpm maximum.

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

E. Temperature Activated Mixing Valves:
1. Application: Emergency eye/face/drench shower equipment.
2. Standard: ASSE 1071.
3. Pressure Rating: 861 kPa (125 psig).
4. Type: Thermostatically controlled water mixing valve set at 24-30 degrees C (75-85 degrees F).
5. Connections: Soldered or threaded union inlets and outlet.
6. Thermometers shall be provided to indicate mixed water temperature.
7. Upon cold water supply failure the hot water flow shall automatically be reduced to 0.5 gpm maximum.

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 shall 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 prohibited for this application.

G. Install pressure gauges on outlet of backflow preventers.

H. Do not install bypass piping around backflow preventers.

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

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

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

K. Install thermostatic balancing valves with inlet strainer and inlet and outlet isolation valves.

3.3 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:

1. Calibrated balancing valves.

2. Thermostatic, water mixing valves.

B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit.

3.4 ADJUSTING

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

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

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

D. Testing and adjusting of balancing valves shall be performed by an independent NEBB Accredited Test and Balance Contractor. A final settings and flow report shall be submitted to the VA Contracting Officer’s Representative (COR).

3.5 STARTUP AND TESTING

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

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

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

3.6 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 33
HEAT TRACING FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

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

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

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

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

C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

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

E. Section 22 07 11, PLUMBING INSULATION.

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

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

1.3 APPLICABLE PUBLICATIONS

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

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

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

C. International Code Council, (ICC):

IPC-2018................International Plumbing Code

D. National Fire Protection Association (NFPA):

70–2020.................National Electrical Code (NEC)

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

508-2018................Industrial Control Equipment

1.4 SUBMITTALS

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

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

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

1. Rated capacity.
2. Length of cable.
3. Cable spacing.
4. Electrical power requirements.
5. Controls.
6. Enclosures.
7. Accessories.

D. The shop drawings shall include plans, sections, details, wiring diagrams, and attachments to other work. The wiring diagrams shall include power, signal, and control wiring.

E. Field quality control test reports shall be submitted.

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

1. Include complete list indicating all components of the systems.
2. Include complete diagrams of the internal wiring for each item of equipment.
3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

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

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

1.5 QUALITY ASSURANCE

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

B. Product Requirements:

1. Pipe or tank tracing cable assembly shall be factory assembled, immersed in water for a minimum of 12 hours, and then tested for insulation resistance, high potential breakdown and continuity before leaving the factory.
2. Factory Mutual approved heating cable that has the same wattage per lineal foot (power output), throughout its entire length.
3. UL Listed, thermostat and contactor panel.
4. UL Listed Control/Monitor Panel.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

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

1.6 AS-BUILT DOCUMENTATION

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

PART 2 - PRODUCTS

2.1 SELF-REGULATING PARALLEL RESISTANCE HEATING CABLES

A. Self-regulating parallel resistance heating cables shall comply with IEEE 515.1.

B. The heating element shall be a pair of parallel No. 16 AWG tinned stranded copper bus wires embedded in cross linked conductive polymer core, which varies heat output in response to temperature along its length. Cables shall be terminated with waterproof, factory assembled non heating leads with connects at one and seal the opposite end watertight. The cable shall be capable of crossing over itself without overheating.

C. The electrical insulating jacket shall be flame-retardant polyolefin.

D. The cable cover shall be tinned copper braid and polyolefin outer jacket with UV inhibitor.

E. The maximum power on operating temperature shall be 65 degrees C (150 degrees F).

F. The maximum power off exposure temperature shall be 85 degrees C (185 degrees F).

G. The capacities and characteristics shall be:

1. Maximum heat output 26.0 W/m (8.0 W/foot).
2. Pipe Diameter: 4 inch.
3. Number of parallel cables: Two.
4. See electrical drawings for electrical characteristics.

2.2 CONTROLS

A. Pipe mounting thermostats for Freeze protection shall have be a remote bulb unit with adjustable temperature range from minus 1 to 10 degrees C (34 to 50 degrees F). The thermostat shall be snap action, open-on-rise, single pole switch with minimum current rating adequate for the connected cable. The thermostat shall be remote bulb on capillary, resistance temperature device, or thermistor for direct sensing of pipe wall temperature. The control enclosure shall be corrosion resistant and waterproof.

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

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

2.3 ACCESSORIES

A. Cable Installation Accessories: Fiberglass tape, heat-conductive putty, cable ties, silicone end seals and splice kits, and installation clips all furnished by manufacturer, or as recommended in writing by manufacturer.

B. Warning Labels: Shall comply with NFPA 70.

C. Warning Tape: Continuously printed "Electrical Tracing"; vinyl, at least 0.08 mm (3 mils) thick, and with pressure-sensitive, permanent, waterproof, self-adhesive back.
   1. Width for Warning Tape on Pipes with Outside Dimension, Including Insulation, Less Than 150 mm (6 inches): 19 mm (3/4 inch) minimum.
   2. Width for Warning Tape on Pipes with Outside Dimension, Including Insulation, 150 mm (6 inches) or Greater: 38 mm (1-1/2 inches) minimum.

PART 3 - EXECUTION

3.1 GENERAL

A. Inspect surfaces and substrates of electric heating cables for compliance with requirements of this specification. Ensure surfaces and pipes in contact with electric heating cables are free of burrs and sharp protrusions.

B. Notify COR if the existing substrate conditions are unsuitable for application of heating cables in accordance with manufacturer’s recommendations.

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

3.2 INSTALLATION

A. Electric heating cable shall be installed for the following applications:
   1. Freeze protection of plumbing piping: Self-regulating parallel-resistance heating cable.

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

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

D. Electric heating cable for pipe freeze protection shall be installed according to the following:

1. Electric heating cables shall be installed after piping has been tested and before insulation is installed.
2. Electric heat cables shall be installed according to IEEE 515.1
3. Insulation shall be installed or applied over piping with electric cables. Refer to Section 22 07 11, PLUMBING INSULATION.
4. Warning tape shall be installed on pipe insulation where piping is equipped with electric heating cables.
5. Provide current transducer to monitor power in heating tape and monitor and alarm from BAS.

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

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

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

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

3.3 TESTS

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

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

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

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

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

E. Prepare test and inspection reports.

F. .

3.4 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer’s technical representative for 4 hours to instruct each VA personnel responsible in operation and maintenance of the system.

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

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SECTION 22 07 11
PLUMBING INSULATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. Field applied insulation for thermal efficiency and condensation control for the following:
   1. Plumbing piping and equipment.
   2. Re-insulation of plumbing piping and equipment after asbestos abatement and or replacement of any part of existing insulation system (insulation, vapor retarder jacket, protective coverings/jacket) damaged during construction.

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

10. Thermal conductance: Heat flow rate through materials.
    a. Flat surface: Watts per square meter (BTU per hour per square foot).
    b. Pipe or Cylinder: Watts per linear meter (BTU per hour per linear foot) for a given outside diameter.
11. Thermal Conductivity (k): Watts per meter, per degree K (BTU - inch thickness, per hour, per square foot, per degree F temperature difference).
12. Vapor Retarder (Vapor Barrier): A material which retards the transmission (migration) of water vapor. Performance of the vapor retarder is rated in terms of permeance (perms). For the purpose of this specification, vapor retarders/vapor barriers shall have a maximum published permeance of .02 perms.
13. DHWR: Domestic Hot water recirculating.
14. DCW: Domestic Cold water.
15. SW: Soft water.
16. DHW: Domestic Hot water.
17. PVDC: Polyvinylidene chloride vapor retarder jacketing, white.
18. RO: Reverse Osmosis water.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.
B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.
D. Section 02 82 11, TRADITIONAL ASBESTOS ABATEMENT: Insulation containing asbestos material.
E. Section 07 84 00, FIRESTOPPING: Mineral fiber and bond breaker behind sealant.
F. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING: General mechanical requirements and items, which are common to more than one section of Division 22.
G. Section 22 05 19, METERS AND GAGES FOR PLUMBING PIPING: Hot and cold water piping.
H. Section 22 05 23, GENERAL-DUTY VALVES FOR PLUMBING PIPING: Hot and cold water piping.
I. Section 22 05 33, HEAT TRACING FOR PLUMBING PIPING: Insulation over heating cables.

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 basic designation only.

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

C411-2011...............Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation

C449-2007 (R2013).......Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement

C450-2008 (R2014).......Standard Practice for Fabrication of Thermal Insulating Fitting Covers for NPS Piping, and Vessel Lagging

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

C534/C534M-2014.........Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form

C547-2015...............Standard Specification for Mineral Fiber Pipe Insulation

C552-2014...............Standard Specification for Cellular Glass Thermal Insulation

C612-2014...............Standard Specification for Mineral Fiber Block and Board Thermal Insulation

C1136-2012..............Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation

C1710-2011..............Standard Guide for Installation of Flexible Closed Cell Preformed Insulation in Tube and Sheet Form

D1668/D1668M-1997a (2014)e1 Standard Specification for Glass Fabrics (Woven and Treated) for Roofing and Waterproofing

E84-2015a...............Standard Test Method for Surface Burning Characteristics of Building Materials

E2231-2015..............Standard Practice for Specimen Preparation and Mounting of Pipe and Duct Insulation to Assess Surface Burning Characteristics

C. Federal Specifications (Fed. Spec.):

L-P-535E-1979...........Plastic Sheet (Sheeting): Plastic Strip; Poly (Vinyl Chloride) and Poly (Vinyl Chloride - Vinyl Acetate), Rigid.

D. International Code Council, (ICC):

IMC-2012................International Mechanical Code

E. Military Specifications (Mil. Spec.):

MIL-A-3316C (2)-1990....Adhesives, Fire-Resistant, Thermal Insulation

MIL-A-24179A (2)-1987...Adhesive, Flexible Unicellular-Plastic Thermal Insulation

MIL-PRF-19565C (1)-1988.Coating Compounds, Thermal Insulation, Fire-and Water-Resistant, Vapor-Barrier

MIL-C-20079H-1987.......Cloth, Glass; Tape, Textile Glass; and Thread, Glass and Wire-Reinforced Glass

F. National Fire Protection Association (NFPA):

90A-2015................Standard for the Installation of Air-Conditioning and Ventilating Systems

G. Underwriters Laboratories, Inc (UL):

723-2008 (R2013)........Standard for Test for Surface Burning Characteristics of Building Materials

1887-2004 (R2013).......Standard for Fire Test of Plastic Sprinkler Pipe for Visible Flame and Smoke Characteristics

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

1.4 SUBMITTALS

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

B. Information and material submitted under this section shall be marked “SUBMITTED UNDER SECTION 22 07 11, PLUMBING INSULATION”, with applicable paragraph identification.

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

D. Shop Drawings:

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

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

1.5 QUALITY ASSURANCE

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

B. Criteria:

1. Comply with NFPA 90A, particularly paragraphs 4.3.3.1 through 4.3.3.6, 4.3.11.2.6, parts of which are quoted as follows:

    4.3.3.1 Pipe and duct insulation and coverings, duct linings, vapor retarder facings, adhesives, fasteners, tapes, and supplementary materials added to air ducts, plenums, panels and duct silencers used in duct systems shall have, in the form in which they are used, a maximum flame spread index of 25 without evidence of continued progressive combustion and a maximum smoke developed index of 50 when tested in accordance with ASTM E84 and appropriate mounting practice, e.g. ASTM E2231.

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

4.3.11.2.6.3 Nonferrous fire sprinkler piping shall be listed as having a maximum peak optical density of 0.5 or less, an average optical density of 0.15 or less, and a maximum flame spread distance of 1.5 m (5 ft) or less when tested in accordance with UL 1887, Standard for Safety Fire Test of Plastic Sprinkler Pipe for Visible Flame and Smoke Characteristics.

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

2. Test methods: ASTM E84, UL 723, and ASTM E2231.
3. Specified k factors are at 24 degrees C (75 degrees F) mean temperature unless stated otherwise. Where optional thermal insulation material is used, select thickness to provide thermal conductance no greater than that for the specified material. For pipe, use insulation manufacturer's published heat flow tables. For domestic hot water supply and return, run out insulation and condensation control insulation, no thickness adjustment need be made.
4. All materials shall be compatible and suitable for service temperature and shall not contribute to corrosion or otherwise attack surface to which applied in either the wet or dry state.

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

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

1.6 AS-BUILT DOCUMENTATION

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

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

C. Certification documentation shall be provided prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and certification that all results of tests were within limits specified.

1.7 STORAGE AND HANDLING OF MATERIAL

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

PART 2 - PRODUCTS

2.1 MINERAL FIBER OR FIBER GLASS

A. ASTM C547 (Pipe Fitting Insulation and Preformed Pipe Insulation), Class 1, k = 0.037 (0.26) at 24 degrees C (75 degrees F), for use at temperatures up to 230 degrees C (446 degrees F) with an all-service vapor retarder jacket (ASJ) and with polyvinyl chloride (PVC) premolded fitting covering.

2.2 MINERAL WOOL OR REFRACTORY FIBER

A. Comply with Standard ASTM C612, Class 3, 450 degrees C (842 degrees F).

2.3 CELLULAR GLASS CLOSED-CELL

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

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

C. Pipe insulation for use at process temperatures for pipe and tube below ambient air temperatures or where condensation control is necessary are to be installed with a vapor retarder/barrier system of with or without all service vapor retarder sealed jacket (ASJ) system. Without ASJ shall require all longitudinal and circumferential joints to be vapor sealed with vapor barrier mastic.

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

2.4 FLEXIBLE ELASTOMERIC CELLULAR THERMAL

A. ASTM C534/C534M, k = 0.039 (0.27) at 24 degrees C (75 degrees F), flame spread not over 25, smoke developed not over 50, for temperatures from minus 4 degrees C (40 degrees F) to 93 degrees C (199 degrees F). Under high humidity exposures for condensation control an external vapor retarder/barrier jacket is required. Consult ASTM C1710.

2.5 INSULATION FACINGS AND JACKETS

A. Vapor Retarder, higher strength with low water permeance = 0.02 or less perm rating, Beach puncture 50 units for insulation facing on pipe insulation jackets. Facings and jackets shall be ASJ or PVDC Vapor Retarder jacketing.

B. ASJ shall be white finish (kraft paper) bonded to 0.025 mm (1 mil) thick aluminum foil, fiberglass reinforced, with pressure sensitive adhesive closure. Comply with ASTM C1136. Beach puncture is 50 units, suitable for painting without sizing. Jackets shall have minimum 40 mm (1-1/2 inch) lap on longitudinal joints and minimum 75 mm (3 inch) butt strip on end joints. Butt strip material shall be same as the jacket.

Lap and butt strips shall be self-sealing type with factory-applied pressure sensitive adhesive.

C. Vapor Retarder medium strength with low water vapor permeance of 0.02 or less perm rating), Beach puncture 25 units: FSK or PVDC type for concealed ductwork and equipment.

D. Except for flexible elastomeric cellular thermal insulation (not for high humidity exposures), field applied vapor barrier jackets shall be provided, in addition to the specified facings and jackets, on all exterior piping as well as on interior piping exposed to outdoor air (i.e., in ventilated attics, piping in ventilated (not air conditioned) spaces, etc.) in high humidity locations, conveying fluids below ambient temperature. The vapor barrier jacket shall consist of a multi-layer laminated cladding with a maximum water vapor permeance of 0.001 perms. The minimum puncture resistance shall be 35 cm-kg (30 inch-pounds) for interior locations and 92 cm-kg (80 inch-pounds) for exterior or exposed locations or where the insulation is subject to damage.

E. Except for cellular glass thermal insulation, when all longitudinal and circumferential joints are vapor sealed with a vapor barrier mastic or caulking, vapor barrier jackets may not be provided. For aesthetic and physical abuse applications, exterior jacketing is recommended. Otherwise, field applied vapor barrier jackets shall be provided, in addition to the applicable specified facings and jackets, on all exterior piping as well as on interior piping exposed to outdoor air (i.e., in ventilated attics, piping in ventilated (not air conditioned) spaces, etc.) in high humidity locations conveying fluids below ambient temperature. The vapor barrier jacket shall consist of a multi-layer laminated cladding with a maximum water vapor permeance of 0.001 perms. The minimum puncture resistance shall be 35 cm-kg (30 inch-pounds) for interior locations and 92 cm-kg (80 inch-pounds) for exterior or exposed locations or where the insulation is subject to damage.

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

G. Pipe fitting insulation covering (jackets): Fitting covering shall be premolded to match shape of fitting and shall be PVC conforming to Fed Spec L-P-535E, composition A, Type II Grade GU, and Type III, minimum thickness 0.7 mm (0.03 inches). Provide color matching vapor retarder pressure sensitive tape. Staples, tacks, or any other attachment that penetrates the PVC covering is not allowed on any form of a vapor barrier system in below ambient process temperature applications.

2.6 PIPE COVERING PROTECTION SADDLES

A. Cold pipe support: Premolded pipe insulation 180 degrees (half-shells) on bottom half of pipe at supports. Material shall be cellular glass insulation of the same thickness as adjacent insulation.

Nominal Pipe Size and Accessories Material (Insert Blocks)	
Nominal Pipe Size mm (inches)	**Insert Blocks mm (inches)**
Up through 125 (5)	150 (6) long
150 (6)	150 (6) long
200 (8), 250 (10), 300 (12)	225 (9) long
350 (14), 400 (16)	300 (12) long
450 through 600 (18 through 24)	350 (14) long

B. Warm or hot pipe supports: Premolded pipe insulation (180-degree half-shells) on bottom half of pipe at supports. Material shall be cellular glass or calcium silicate. Insulation at supports shall have same thickness as adjacent insulation.

2.7 ADHESIVE, MASTIC, CEMENT

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

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

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

D. Mil. Spec. MIL-PRFC-19565C, Type I or Type II: Vapor barrier compound for indoor use.

E. ASTM C449: Mineral fiber hydraulic-setting thermal insulating and finishing cement.
F. Other: Insulation manufacturers' published recommendations.

2.8 MECHANICAL FASTENERS

A. Pins, anchors: Welded pins, or metal or nylon anchors with galvanized steel or fiber washer, or clips. Pin diameter shall be as recommended by the insulation manufacturer.
B. Staples: Outward clinching galvanized steel. Staples are not allowed for below ambient vapor barrier applications.
C. Wire: 1.3 mm thick (18 gage) soft annealed galvanized or 1.9 mm (14 gage) copper clad steel or nickel copper alloy or stainless steel.
D. Bands: 13 mm (1/2 inch) nominal width, brass, galvanized steel, aluminum or stainless steel.
E. Tacks, rivets, screws or any other attachment device capable of penetrating the vapor retarder shall NOT be used to attach/close the any type of vapor retarder jacketing. Thumb tacks sometimes used on PVC jacketing and preformed fitting covers closures are not allowed for below ambient vapor barrier applications.

2.9 REINFORCEMENT AND FINISHES

A. Glass fabric, open weave: ASTM D1668/D1668M, Type III (resin treated) and Type I (asphalt or white resin treated).
B. Glass fiber fitting tape: Mil. Spec MIL-C-20079H, Type II, Class 1.
C. Tape for Flexible Elastomeric Cellular Insulation: As recommended by the insulation manufacturer.
D. PVC fitting cover: Fed. Spec L-P-535E, Composition A, 11-86 Type II, Grade GU, with Form B Mineral Fiber insert, for media temperature 10 to 121 degrees C (50 to 250 degrees F). Below 10 degrees C (50 degrees F) and above 121 degrees C (250 degrees F) provide mitered pipe insulation of the same type as insulating straight pipe. Provide double layer insert. Provide vapor barrier pressure sensitive tape matching the color of the PVC jacket.

2.10 FIRESTOPPING MATERIAL

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

2.11 FLAME AND SMOKE

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

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

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

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

C. Where removal of insulation of piping and equipment is required to comply with Section 02 82 11, TRADITIONAL ASBESTOS ABATEMENT, such areas shall be reinsulated to comply with this specification.

D. Insulation materials shall be installed with smooth and even surfaces, with jackets and facings drawn tight and smoothly cemented down and sealed at all laps. Insulation shall be continuous through all sleeves and openings, except at fire dampers and duct heaters (NFPA 90A).

E. Vapor retarders shall be continuous and uninterrupted throughout systems with operating temperature 15 degrees C (60 degrees F) and below. Lap and seal vapor barrier over ends and exposed edges of insulation. Anchors, supports and other metal projections through insulation on cold surfaces shall be insulated and vapor sealed for a minimum length of 150 mm (6 inches).

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

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

H. Insulation on hot piping and equipment shall be terminated square at items not to be insulated, access openings and nameplates. Cover all exposed raw insulation with white sealer coating (caution about coating's maximum temperature limit) or jacket material.

I. Protect all insulations outside of buildings with aluminum jacket using lock joint or other approved system for a continuous weather tight system. Access doors and other items requiring maintenance or access shall be removable and sealable J. Apply insulation materials subject to the manufacturer's recommended temperature limits. Apply adhesives, mastic and coatings at the manufacturer's recommended minimum wet or dry film thickness. Bio-based materials shall be utilized when possible.

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

L. Freeze protection of above grade outdoor piping (overheat tracing tape): 20 mm (3/4 inch) thick insulation, for all pipe sizes 75 mm (3 inches) and smaller and 25 mm (1 inch) thick insulation for larger pipes. Provide metal jackets for all pipe insulations. Provide freeze protection for cold water make-up piping and equipment where indicated on the drawings as described in Section 23 21 13, HYDRONIC PIPING (electrical heat tracing systems).

M. Provide vapor barrier systems as follows:
   1. All piping exposed to outdoor weather.
   2. All interior piping conveying fluids exposed to outdoor air (i.e., in attics, ventilated (not air conditioned) spaces, etc.) below ambient air temperature in high humidity locations.

N. Provide PVC jackets over insulation as follows:

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

3.2 INSULATION INSTALLATION

A. Molded Mineral Fiber Pipe and Tubing Covering:
   1. Fit insulation to pipe, aligning all longitudinal joints. Seal longitudinal joint laps and circumferential butt strips by rubbing hard with a nylon sealing tool to assure a positive seal. Staples may be used to assist in securing insulation except for cold piping. Seal all vapor retarder penetrations on cold piping with a generous application of vapor barrier mastic. Provide cellar glass inserts and install with metal insulation shields at outside pipe supports. Install freeze protection insulation over heating cable.
   2. Contractor's options for fitting, flange and valve insulation:
      a. Insulating and finishing cement for sizes less than 100 mm (4 inches) operating at surface temperature of 15 degrees C (60 degrees F) or more.
      b. Factory premolded, one piece PVC covers with mineral fiber, (Form B), inserts surface temperature of above 4 degrees C (40 degrees F) to 121 degrees C (250 degrees F). Provide mitered preformed insulation of the same type as the installed straight pipe insulation for pipe temperatures below 4 degrees C (40 degrees F). Secure first layer of mineral fiber insulation with twine. Seal seam edges with vapor barrier mastic and secure with fitting tape.
      c. Factory preformed, ASTM C547 or fabricated mitered sections, joined with adhesive or (hot only) wired in place. (Bio-based materials shall be utilized when possible.) For hot piping finish with a smoothing coat of finishing cement. For cold fittings, 15 degrees C (60 degrees F) or less, vapor seal with a layer of glass fitting tape imbedded between two 2 mm (1/16 inch) coats of vapor barrier mastic.
      d. Fitting tape shall extend over the adjacent pipe insulation and overlap on itself at least 50 mm (2 inches).

3. Nominal thickness in millimeters and inches specified in the schedule at the end of this section.

B. Cellular Glass Insulation:

1. Pipe and tubing, covering nominal thickness in millimeters and inches as specified in the schedule at the end of this section.
2. Cold equipment: 50 mm (2 inch) thick insulation faced with ASJ.

C. Flexible Elastomeric Cellular Thermal Insulation:

1. Apply insulation and fabricate fittings in accordance with the manufacturer's installation instructions and finish with two coats of weather resistant finish as recommended by the insulation manufacturer. External vapor barrier jacketing may be required for expected or anticipated high humidity exposures. See ASTM C1710.
2. Pipe and tubing insulation:
   a. Use proper size material. Do not stretch or strain insulation.
   b. To avoid undue compression of insulation, use supports as recommended by the elastomeric insulation manufacturer. Insulation shields are specified under Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.
   c. Where possible, slip insulation over the pipe or tubing prior to connection, and seal the butt joints with adhesive. Where the slip-on technique is not possible, slit the insulation and apply it to the pipe sealing the seam and joints with contact adhesive. Optional tape sealing, as recommended by the manufacturer, may be employed. Bio-based materials shall be utilized when possible.
3. Apply sheet insulation to flat or large curved surfaces with 100 percent adhesive coverage. For fittings and large pipe, apply adhesive to seams only.
4. Pipe insulation: nominal thickness in millimeters (inches as specified in the schedule at the end of this section.

3.3 COMMISSIONING

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

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

3.4 PIPE INSULATION SCHEDULE

A. Provide insulation for piping systems as scheduled below:

Insulation Thickness Millimeters (Inches)					
		Nominal Pipe Size Millimeters (Inches)			
Operating Temperature Range/Service	**Insulation Material**	**Less than 25 (1)**	**25 – 32 (1 – 1¼)**	**38 – 75 (1½ - 3)**	**100 (4) and Greater**
38-60 degrees C (100-140 degrees F) (Domestic Hot Water Supply and Return)	Mineral Fiber (Above ground piping only)	38 (1.5)	38 (1.5)	50 (2.0)	50 (2.0)
38-60 degrees C (100-140 degrees F) (Domestic Hot Water Supply and Return)	Flexible Elastomeric Cellular Thermal (Above ground piping only)	38 (1.5)	38 (1.5)	50 (2.0)	50 (2.0)
38-60 degrees C (100-140 degrees F) (Domestic Hot Water Supply and Return)	Cellular Glass Thermal	38 (1.5)	38 (1.5)	50 (2.0)	50 (2.0)
(4-15 degrees C (40-60 degrees F) (Domestic cold water piping and Reverse Osmosis piping)	Flexible Elastomeric Cellular Thermal (Above ground piping only)	25 (1.0)	25(1.0)	25 (1.0)	25 (1.0)
4-15 degrees C (40-60 degrees F) (Domestic Cold Water piping)	Mineral Fiber (Above ground piping only)	15 (0.5)	25(1.0)	25(1.0)	25(1.0)
4-15 degrees C (40-60 degrees F) (Domestic Cold Water piping and Reverse Osmosis piping)	Cellular Glass Thermal	38 (1.5)	38 (1.5)	38 (1.5)	38 (1.5)

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SECTION 22 08 00
COMMISSIONING OF PLUMBING SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

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

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

1.2 RELATED WORK

A. Section 01 00 00 GENERAL REQUIREMENTS.

B. Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS.

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

1.3 SUMMARY

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

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

1.4 DEFINITIONS

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

1.5 COMMISSIONED SYSTEMS

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

B. The Plumbing systems commissioning will include the systems listed in Section 01 91 00 General Commissioning Requirements:

1.6 SUBMITTALS

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

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

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 CONSTRUCTION INSPECTIONS

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

3.2 PRE-FUNCTIONAL CHECKLISTS

A. The Contractor shall complete Pre-Functional Checklists to verify systems, subsystems, and equipment installation is complete, meets design and equipment specifications, and systems are ready for Systems Functional Performance Testing. The Commissioning Agent will prepare Pre-Functional Checklists to be used to document equipment installation, ensure operation and maintenance personnel have adequate access for servicing, and work involves proper workmanship. The Contractor shall complete the checklists. Completed checklists shall be submitted to the VA and to the Commissioning Agent for review. The Commissioning Agent may spot check a sample of completed checklists. If the Commissioning Agent determines that the information provided on the checklist is not accurate, the Commissioning Agent will return the marked-up checklist to the Contractor for correction and resubmission. If the Commissioning Agent determines that a significant number of completed checklists for similar equipment are not accurate, the

Commissioning Agent will select a broader sample of checklists for review. If the Commissioning Agent determines that a significant number of the broader sample of checklists is also inaccurate, all the checklists for the type of equipment will be returned to the Contractor for correction and resubmission. Refer to SECTION 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for submittal requirements for Pre-Functional Checklists, Equipment Startup Reports, and other commissioning documents.

3.3 CONTRACTORS TESTS

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

3.4 SYSTEMS FUNCTIONAL PERFORMANCE TESTING:

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

3.5 TRAINING OF VA PERSONNEL

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

----- END -----

SECTION 22 11 00
FACILITY WATER DISTRIBUTION

PART 1 - GENERAL

1.1 DESCRIPTION

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

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

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

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

C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

D. Section 07 84 00, FIRESTOPPING.

E. Section 07 92 00, JOINT SEALANTS.

F. Section 09 91 00, PAINTING.

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

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

B16.15-2013 ....Cast Copper Alloy Threaded Fittings: Classes 125 and 250

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

ASME Boiler and Pressure Vessel Code -

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):

A47/A47M-1999 (R2014)...Standard Specification for Ferritic Malleable Iron Castings

A53/A53M-2012...........Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

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

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

B75/B75M-2011...........Standard Specification for Seamless Copper Tube

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

B584-2014...............Standard Specification for Copper Alloy Sand Castings for General Applications

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

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

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

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

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

1.4 SUBMITTALS

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

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

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

1. All items listed in Part 2 - Products.

D. Complete operating and maintenance manuals including wiring diagrams, technical data sheets and information for ordering replacement parts:

1. Include complete list indicating all components of the systems.
2. Include complete diagrams of the internal wiring for each item of equipment.
3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

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

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

1.5 QUALITY ASSURANCE

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

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

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

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

1.6 AS-BUILT DOCUMENTATION

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

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

C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. As-built drawings are to be provided, and a copy of them in Auto-CAD version 14 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 UNDERGROUND WATER SERVICE CONNECTIONS TO BUILDINGS

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

B. 75 mm (3 inch) Diameter and Greater: Ductile iron, AWWA C151, 2413 kPa (350 psig) pressure class, exterior bituminous coating, and cement lined. Bio-based materials shall be utilized when possible. Provide flanged and anchored connection to interior piping.

C. Under 75 mm (3 inch) Diameter: Copper tubing, ASTM B88, Type K, seamless, annealed. Fittings are as specified in paragraph “Above Ground (Interior) Water Piping”. Use brazing alloys, AWS A5.8M/A5.8, Classification BCuP.

2.3 ABOVE GROUND (INTERIOR) WATER PIPING

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

B. Fittings for Copper Tube:

1. Wrought copper or bronze castings conforming to ASME B16.18 and B16.22. Unions shall be bronze, MSS SP-72, MSS SP-110, solder or braze joints. Use 95/5 tin and antimony for all soldered joints.
2. Grooved fittings, 50 to 150 mm (2 to 6 inch) wrought copper ASTM B75/B75M C12200, , C84400. Mechanical grooved couplings, 2070 kPa (300 psig) minimum ductile iron, ASTM A536 Grade 448-310-12 (Grade 65-45-12), or malleable iron, ASTM A47/A47M Grade 22410 (Grade 32510) housing, with EPDM gasket, steel track head bolts, ASTM A183, coated with copper colored alkyd enamel.
3. Mechanical press-connect fittings for copper pipe and tube **are prohibited**. See Plumbing Design Manual for additional information.
4. Flanged fittings, bronze, class 150, solder-joint ends conforming to ASME B16.24.

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

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

E. 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.

F. Re-agent Grade Water Piping and Dialysis Water Piping:

1. Reverse Osmosis (RO) Water Piping:
   a. Low Pressure Feed, Reject and Recycle Piping: Less than or equal to 520 kPa (75 psig): ASTM D1785, Schedule 80 PVC, ASTM D2855 socket welded and flanged.
   b. RO Product Tubing from each Membrane Housing: ASTM D1785, Schedule 80 PVC, ASTM D2855 socket welded and flanged.
   c. Low Pressure Control and Pressure Gage Tubing: Polyethylene.

d. High Pressure Reject and Recycle Piping: Greater than 520 kPa (75 psig): ASTM A269/A269M, Type 304 schedule 10 stainless steel with butt welded joints.

e. High Pressure Control and Pressure Gage Tubing: 6895 kPa (1000 psig) burst nylon.

2.4 EXPOSED WATER PIPING

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

1. Pipe: ASTM B43, standard weight.
2. Fittings: ASME B16.15 cast bronze threaded fittings with chrome finish.
3. Nipples: ASTM B687, Chromium-plated.
4. Unions: MSS SP-72, MSS SP-110, brass or bronze with chrome finish. Unions 65 mm (2-1/2 inches) and larger shall be flange type with approved gaskets.

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

2.5 ETHYLENE OXIDE (ETO) STERILIZER WATER SUPPLY PIPING

A. Stainless steel, ASTM A312, Schedule 10 with stainless-steel butt-welded fittings. Provide on sterilizer water supply.

2.6 TRAP PRIMER WATER PIPING

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

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

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

2.7 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.

2.8 DIELECTRIC FITTINGS

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

2.9 STERILIZATION CHEMICALS

A. Hypochlorite: ASTM E1229.

B. Liquid Chlorine: ASTM E1120.

2.10 WATER HAMMER ARRESTER

A. Closed copper tube chamber with permanently sealed 413 kPa (60 psig) air charge above a Double O-ring piston. Two high heat Buna-N 0-rings pressure packed and lubricated with FDA approved silicone compound. All units shall be designed in accordance with ASSE 1010. Access shall be provided where devices are concealed within partitions or above ceilings. Size and install in accordance with PDI-WH 201 requirements. Provide water hammer arrestors at:

1. All solenoid valves.
2. All groups of two or more flush valves.
3. All quick opening or closing valves.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General: Comply with the International Plumbing Code and the following:

1. Install branch piping for water from the piping system and connect to all fixtures, valves, cocks, outlets, casework, cabinets and equipment, including those furnished by the Government or specified in other sections.
2. Pipe shall be round and straight. Cutting shall be done with proper tools. Pipe, except for plastic and glass, shall be reamed to remove burrs and a clean smooth finish restored to full pipe inside diameter.
3. All pipe runs shall be laid out to avoid interference with other work/trades.
4. Install union and shut-off valve on pressure piping at connections to equipment.
5. Pipe Hangers, Supports and Accessories:
   a. All piping shall be supported per the IPC, H-18-8 Seismic Design Handbook, MSS SP-58, and SMACNA as required.

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

c. Floor, Wall and Ceiling Plates, Supports, Hangers:

1) Solid or split un-plated cast iron.
2) All plates shall be provided with set screws.
3) Pipe Hangers: Height adjustable clevis type.
4) Adjustable Floor Rests and Base Flanges: Steel.
5) Concrete Inserts: "Universal" or continuous slotted type.
6) Hanger Rods: Mild, low carbon steel, fully threaded or Threaded at each end with two removable nuts at each end for positioning rod and hanger and locking each in place.
7) Pipe Hangers and Riser Clamps: Malleable iron or carbon steel. Pipe Hangers and riser clamps shall have a copper finish when supporting bare copper pipe or tubing.
8) Rollers: Cast iron.
9) Self-drilling type expansion shields shall be "Phillips" type, with case hardened steel expander plugs.
10) Hangers and supports utilized with insulated pipe and tubing shall have 180-degree (minimum) metal protection shield centered on and welded to the hanger and support. The shield thickness and length shall be engineered and sized for distribution of loads to preclude crushing of insulation without breaking the vapor barrier. The shield shall be sized for the insulation and have flared edges to protect vapor-retardant jacket facing. To prevent the shield from sliding out of the clevis hanger during pipe movement, center-ribbed shields shall be used.
11) Miscellaneous Materials: As specified, required, directed or as noted on the drawings for proper installation of hangers, supports and accessories. If the vertical distance exceeds 6.1 m (20 feet) for cast iron pipe additional support shall be provided in the center of that span. Provide all necessary auxiliary steel to provide that support.

12) With the installation of each flexible expansion joint, provide piping restraints for the upstream and downstream section of the piping at the flexible expansion joint. Provide calculations supporting the restraint length design and type of selected restraints. Restraint calculations shall be based on the criteria from the manufacturer regarding their restraint design.

6. Install chrome plated cast brass escutcheon with set screw at each wall, floor and ceiling penetration in exposed finished locations and within cabinets and millwork.
7. Penetrations:
   a. Firestopping: Where pipes pass through fire partitions, fire walls, smoke partitions, or floors, install a fire stop that provides an effective barrier against the spread of fire, smoke, and gases as specified in Section 07 84 00, FIRESTOPPING. Completely fill and seal clearances between raceways and openings with the firestopping materials.
   b. Waterproofing: At floor penetrations, completely seal clearances around the pipe and make watertight with sealant as specified in Section 07 92 00, JOINT SEALANTS. Bio-based materials shall be utilized when possible.
   c. Acoustical sealant: Where pipes pass through sound rated walls, seal around the pipe penetration with an acoustical sealant that is compliant with ASTM C919.

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

3.2 TESTS

A. General: Test system either in its entirety or in sections. Submit testing plan to COR 10 working days prior to test date.

B. Potable Water System: Test after installation of piping and domestic water heaters, but before piping is concealed, before covering is applied, and before plumbing fixtures are connected. Fill systems with water and maintain hydrostatic pressure of 1035 kPa (150 psig) gage for two hours. No decrease in pressure is allowed. Provide a pressure gage with a shutoff and bleeder valve at the highest point of the piping being tested. Pressure gauge shall have 1 psig increments.

C. Re-agent Grade 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.

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.

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

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SECTION 22 11 23
DOMESTIC WATER PUMPS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Hot water circulating pump, hot water recirculation pump and domestic water pressure booster system.

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

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

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

C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

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

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

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

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

H. 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):

ASME Boiler and Pressure Code -

BPVC Section VIII-1-2015 Rules for Construction of Pressure Vessels, Division 1

BPVC Section VIII-2-2015 Rules for Construction of Pressure Vessels, Division 2-Alternative Rules

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

A48/A48M-2003 (R2012)...Standard Specification for Gray Iron Castings

B584-2014...............Standard Specification for Copper Alloy Sand Castings for General Applications

D. International Code Council (ICC)

IPC-2012................International Plumbing Code

E. National Electrical Manufacturers Association (NEMA):

ICS 6-1993 (R2001, R2006) Industrial Control and Systems: Enclosures

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

F. NSF International (NSF)

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

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

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

508-1999 (R2013)........Standards for Industrial Control Equipment

778-2010 (R2014)........Standard for Motor-Operated Water Pumps

1.4 SUBMITTALS

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

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

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

1. Pump:
   a. Manufacturer and model.
   b. Operating speed.
   c. Capacity.
   d. Characteristic performance curves.
2. Motor:
   a. Manufacturer, frame and type.
   b. Speed.
   c. Current Characteristics.
   d. Efficiency.
3. Tank:
   a. Manufacturer and model.
   b. Capacity

4. Drive: Information in accordance with Section 26 29 11, MOTOR CONTROLLERS.

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

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

F. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replacement parts, and troubleshooting guide:

1. Include complete list indicating all components of the systems.
2. Include complete diagrams of the internal wiring for each item of equipment.
3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

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

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

1.5 QUALITY ASSURANCE

A. General:

1. UL Compliance: Comply with UL 778 for motor-operated water pumps.
2. Design Criteria:
   a. Pump sizes, capacities, pressures, operating characteristics and efficiency shall be as scheduled.
   b. Head-capacity curves shall slope up to maximum head at shut-off. Select pumps near the midrange of the curve, and near the point of maximum efficiency, without approaching the pump curve end point and possible cavitation and unstable operation. Select pumps for open systems so that required net positive suction head (NPSHR) does not exceed the net positive head available (NPSHA).
   c. Pump Driver: Furnish with pump. Size shall be non-overloading at any point on the head-capacity curve, including in a parallel or series pumping installation with one pump in operation.

d. Provide all pumps with motors, impellers, drive assemblies, bearings, coupling guard and other accessories specified. Statically and dynamically balance all rotating parts.
e. Furnish each pump and motor with a nameplate giving the manufacturers name, serial number of pump, capacity in GPM and head in feet at design condition, horsepower, voltage, frequency, speed and full load current and motor efficiency.
f. Test all pumps before shipment. The manufacturer shall certify all pump ratings.
g. After completion of balancing, provide replacement of impellers or trim impellers to provide specified flow at actual pumping head, as installed.

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

C. Non-Potable Water Pressure Booster System:
1. Components shall be furnished by a single manufacturer and the system shall be the standard cataloged product of the manufacturer.
2. Shop Test: Water booster unit and its component parts shall undergo a thorough electric and hydraulic operating test prior to shipment. Tests shall include a system operating flow test from zero to 100 percent of design flow rate under specified suction and system pressure conditions. Certified performance curves shall be furnished.

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

1.6 AS-BUILT DOCUMENTATION

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

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

C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. As-built drawings are to be provided, and a copy of them in Auto-CAD version 14 provided on compact disk or DVD. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the ‘third party testing company’ requirement.

D. Certification documentation shall be provided to COR 10 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and certification that all results of tests were within limits specified.

PART 2 - PRODUCTS

2.1 MATERIALS

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

2.2 HOT WATER RECIRCULATING PUMP

A. General:

1. Centrifugal, single stage, pump. Driver shall be electric motor with variable speed drive, close coupled or connected by flexible or magnetic coupling. Pump for hot water system shall be designed for

quiet, trouble-free operation at a minimum of 82 degrees C (180 degrees F) water service and 1,035 kPa (150 psig).

2. Mounting shall be in-line, vertical or horizontal as indicated on drawing schedules.
3. Stamped or engraved stainless steel nameplate.
4. Motors: Maximum 40 degrees C (104 degrees F) ambient temperature rise, drip-proof, for operation with current, voltage, phase and cycle shown in schedule on Electrical drawings, conforming to NEMA Type 4. Motors shall be equipped with thermal overload protection. When motor has cooled down it shall re-start automatically if the operating control has been left on and the system requires pump to start.
5. Pump shall operate continuously with on-off switch, or with an HOA switch for automatically controlled pumps, for manual shut down. In the inlet and outlet piping of the pump, shutoff valves shall be installed to permit service to the pump, strainer, and check valve without draining the system.
6. A check valve shall be installed in the pump discharge piping immediately downstream of the pump. A strainer with drain valve and removable strainer screen or basket shall be installed immediately upstream of the pump. Flexible pipe connectors and isolation pipe hangers shall be installed to prevent pump vibration from being transferred to adjacent piping and the building structure.

B. Horizontal, Wet-Rotor Circulators:
   1. Maintenance free, close-coupled pump and motor with maximum 3,300 rpm rotational speed.
   2. Stainless steel body construction with ceramic shaft, plastic impeller, fluid lubricated bearings, no mechanical seal, and flanged connections. Pump shall be capable of pumping the capacity scheduled on drawings .
   3. Bearings: Carbon type.
   4. The pump, motor, and variable speed drive shall be an integral product designed and built by the same manufacturer with sensor integrated directly into the pump housing.

5. The pump shall have an integrated operator interface consisting of LED display to signal pump status for quick indication and push button control for speed and pressure setting.
6. Basis of design: Grundfos ALPHA2

2.3 NON-POTABLE WATER PRESSURE BOOSTER SYSTEM

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

B. System Operation and Configuration:
1. System shall automatically maintain constant system pressure as scheduled on drawings.
2. Duplex pump systems shall include both pumps sized for 75 percent of the total capacity.
3. Triplex pump systems shall include a lead pump sized for 75 percent of the total capacity and lag and stand-by pumps sized for 75 percent of the total capacity.

C. Centrifugal Pump: Pumps shall be single stage, in-line pump with variable speed drive motor, low pressure cut-off switches and bypass loops with ball, gate, and check valves as indicated on the Contract Drawings.
1. Impellers: ASTM B584 Cast bronze, radially or vertically split keyed to shaft and secured by a locking cap-screw. Each impeller shall be statically and dynamically balanced prior to assembly in pump casing. Provide replaceable bronze casing wear rings.

2. Pump shaft: Steel, with replaceable bronze shaft sleeve completely covering the wetted area of the shaft under the seal.
3. Lubrication: Water lubricated type pump.
4. Pump Casing: ASTM A48/A48M CL20 Cast iron suitable for 1200 kPa (175 psig). Pump volute shall be supplied with vent and drain tappings. Connections shall be female NPT. The casing shall be O-ring sealed to the seal housing.
5. Seal: Mechanical general purpose type, with sleeve mounting. Seal shall be rated at 1200 kPa (175 psig) maximum.
6. Adjustable Spacer Coupling: Removable type required so that pump seal can be replaced without disturbing motor.
7. Motor: Solid shaft motors balanced to 0.22 mm (0.0085 inch) vibration amplitude shall be operated at any point on the pump head curve without overloading the motor. Conform to NEMA Type 2.

D. Vertical Multistage Pump: Pumps shall be vertical multistage short-coupled pumps with variable speed drive motor, low pressure cut-off switches and bypass loops with ball, butterfly, check valves as indicated on the Contract Drawings.

1. Impellers: Cast bronze, mixed flow enclosed type.
2. Balancing of Impellers: Each impeller shall be statically and dynamically balanced prior to assembly in pump casing.
3. Pump shaft: Stainless steel Type 416.
4. Lubrication: Water lubricated type pump.
5. Pump Bowls: Cast Iron, stainless steel or bronze flanged and bolted.
6. Pump Bearings: Bronze, radial type.
7. Pump Head: Fabricated steel with continuous bypass for low seal pressure. Cast iron heads are prohibited. Pump head shall be lined same as pump barrel.
8. Seal: Mechanical general purpose type, with sleeve mounting. Seal shall be rated at 1200 kPa (175 psig) maximum.
9. Adjustable Spacer Coupling: Removable type required so that pump seal can be replaced without disturbing motor.
10. Motor: Solid shaft motors balanced to 0.22 mm (0.0085 inch) vibration amplitude shall be operated at any point on the pump head curve without overloading the motor. Conform to NEMA Type 2.

11. Pump Barrel: Schedule 40 steel pipe with two-coat "baked" internal lining to meet the potable water requirements of U.S. Food and Drug Administration. Bio-based materials shall be utilized when possible. Unlined pump barrels are prohibited. Provide drain tapping.

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

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

G. Power and Control Panel: Class "A" shadow box double NEMA 1 enclosure, UL labeled, bonderized double prime coated with baked enamel finish:

1. Fused disconnect switches with external operating handles.
2. Magnetic contactor for each motor with HOA switch.
3. Door interlock.
4. Thermal overload protection relay for each motor, three leg type.
5. Running light for each motor.
6. Power light for each motor.
7. Control transformer, switch, circuit breaker, light.
8. Lead pump failure protection.

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

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

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

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

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

PART 3 - EXECUTION

3.1 STARTUP AND TESTING

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

B. System Test: After installation is completed provide an operational test of the completed system including flow rates, pressure compliance, alarms and all control functions.

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

D. The CxA will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the COR and CxA. Contractor shall provide a minimum of 10 working days prior to startup and testing.

3.2 COMMISSIONING

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

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

3.3 DEMONSTRATION AND TRAINING

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

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

- - - E N D - - -

SECTION 22 13 00
FACILITY SANITARY AND VENT PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

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

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

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

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

C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

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

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 22 66 00, Chemical-Waste Systems for Laboratory and Healthcare Facilities

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

M. 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. Where conflicts occur these specifications and the VHA standard will govern.

B. American Society of Mechanical Engineers (ASME):

A13.1-2007..............Identification of Piping Systems

A112.36.2M-1991.........Cleanouts

A112.6.3-2019...........Floor and Trench Drains

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

B16.1-2015..............Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250

B16.4-2016..............Grey Iron Threaded Fittings Classes 125 and 250

B16.15-2018.............Cast Copper Alloy Threaded Fittings, Classes 125 and 250

B16.18-2018.............Cast Copper Alloy Solder Joint Pressure Fittings

B16.21-2016.............Nonmetallic Flat Gaskets for Pipe Flanges

B16.22-2018.............Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings

B16.23-2016.............Cast Copper Alloy Solder Joint Drainage Fittings: DWV

B16.24-2016.............Cast Copper Alloy Pipe Flanges and Flanged Fittings, and Valves: Classes 150, 300, 600, 900, 1500, and 2500

B16.29-2017.............Wrought Copper and Wrought Copper Alloy Solder-Joint Drainage Fittings: DWV

B16.39-2014.............Malleable Iron Threaded Pipe Unions Classes 150, 250, and 300

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):

1001-2017...............Performance Requirements for Atmospheric Type Vacuum Breakers

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

1044-2015...............Performance Requirements for Trap Seal Primer Devices – Drainage Types and Electronic Design Types

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

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

A53/A53M-2018...........Standard Specification for Pipe, Steel, Black And Hot-Dipped, Zinc-coated, Welded and Seamless

A74-2017................Standard Specification for Cast Iron Soil Pipe and Fittings

A888-2018a..............Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications

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

B43-2015................Standard Specification for Seamless Red Brass Pipe, Standard Sizes

B88-2016................Standard Specification for Seamless Copper Water Tube

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

B687-1999(R2016)........Standard Specification for Brass, Copper, and Chromium-Plated Pipe Nipples

B813-2016...............Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube

B828-2016...............Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings

C564-2014...............Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings

D2321-2018..............Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications

F402-2018...............Standard Practice for Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings

F477-2014...............Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe

F1545-2015e1............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

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):

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

G. International Code Council (ICC):

IPC-2018................International Plumbing Code

H. Manufacturers Standardization Society (MSS):

SP-123-2018.............Non-Ferrous Threaded and Solder-Joint Unions for Use with Copper Water Tube

I. National Fire Protection Association (NFPA):

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

J. 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.
8. Exposed Piping and Fittings.

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

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

1. Include complete list indicating all components of the systems.
2. Include complete diagrams of the internal wiring for each item of equipment.
3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

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

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

1.5 QUALITY ASSURANCE

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

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

1.6 AS-BUILT DOCUMENTATION

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

PART 2 - PRODUCTS

2.1 SANITARY WASTE, DRAIN, AND VENT PIPING

A. Cast iron waste, drain, and vent pipe and fittings.
   1. Cast iron waste, drain, and vent pipe and fittings shall be used for the following applications:
      a. Pipe buried in or in contact with earth.
      b. Sanitary pipe extensions to a distance of approximately 1500 mm (5 feet) outside of the building.
      c. Interior waste and vent piping above grade.
   2. Cast iron Pipe shall be bell and spigot or hubless (plain end or no-hub or hubless).
   3. The material for all pipe and fittings shall be cast iron soil pipe and fittings and shall conform to the requirements of CISPI 301, ASTM A888, or ASTM A74.
   4. Cast iron pipe and fittings shall be made from a minimum of 95 percent post-consumer recycled material.
   5. Joints for hubless pipe and fittings shall conform to the manufacturer’s installation instructions. Couplings for hubless joints shall conform to CISPI 310. Joints for hub and spigot pipe shall be installed with compression gaskets conforming to the requirements of ASTM C564.

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

2.2 PUMP DISCHARGE PIPING

A. Galvanized steel pump discharge pipe and fittings:
   1. Galvanized steel pipe shall be Schedule 40 weight class conforming to ASTM A53/A53M, with square cut grooved or threaded ends to match joining method.
   2. Fittings shall be Class 125, gray-iron threaded fittings conforming to ASME B16.4.
   3. Unions shall be Class 150 hexagonal-stock body with ball and socket, metal to metal, bronze seating surface, malleable iron conforming to ASME B16.39 with female threaded ends.
   4. Flanges shall be Class 125 cast iron conforming to ASME B16.1.
      a. Flange gaskets shall be full face, flat nonmetallic, asbestos free conforming to ASME B16.21.
      b. Flange nuts and bolts shall be carbon steel conforming to ASME B18.2.1.

B. Copper pump discharge pipe and fittings:
   1. Copper tube shall be hard drawn Type L conforming to ASTM B88.
   2. Fittings shall be cast copper alloy conforming to ASME B16.18 or wrought copper conforming to ASME B16.22 with solder joint ends.
   3. Unions shall be copper alloy, hexagonal stock body with ball and socket, metal to metal seating surface conforming to MSS SP-123 with female solder-joint or threaded ends.
   4. Flanges shall be Class 150, cast copper conforming to ASME B16.24 with solder-joint end.
      a. Flange gaskets shall be full face, flat nonmetallic, asbestos free conforming to ASME B16.21.
      b. Flange nuts and bolts shall be carbon steel conforming to ASME B18.2.1.
   5. Solder shall be lead free, water flushable flux conforming to ASTM B32 and ASTM B813.

2.3 EXPOSED WASTE PIPING

A. Chrome plated brass piping of full iron pipe size shall be used in finished rooms for exposed waste piping connecting fixtures, casework, cabinets, equipment and reagent racks when not concealed by apron including those furnished by the Government or specified in other sections.

1. The Pipe shall meet ASTM B43, regular weight.
2. The Fittings shall conform to ASME B16.15.
3. Nipples shall conform to ASTM B687, Chromium-plated.
4. Unions shall be brass or bronze with chrome finish. Unions 65 mm (2-1/2 inches) and larger shall be flange type with approved gaskets.

B. In unfinished Rooms such as mechanical Rooms and Kitchens, Chrome-plated brass piping is not required. The pipe materials specified under the paragraph “Sanitary Waste, Drain, and Vent Piping” can be used. The sanitary pipe in unfinished rooms shall be painted as specified in Section 09 91 00, PAINTING.

2.4 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.

2.5 CLEANOUTS

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

B. Floor cleanouts shall be gray iron housing with clamping device and round, secured, scoriated, gray iron cover conforming to ASME A112.36.2M. A gray iron ferrule with hubless, socket, inside calk or spigot connection and counter sunk, taper-thread, brass or bronze closure plug shall be included. The frame and cover material and finish shall be nickel-bronze copper alloy with a square shape. The cleanout shall be vertically adjustable for a minimum of 50 mm (2 inches). When a waterproof membrane is used in the floor system, clamping collars shall be provided on the cleanouts. Cleanouts shall consist of wye fittings and eighth bends with brass or bronze screw plugs. Cleanouts in the resilient tile floors, quarry tile and ceramic tile floors shall be provided with square top covers recessed for tile insertion. In the carpeted areas, carpet cleanout markers shall be provided. Two way cleanouts shall be provided where indicated in the contract document and at every building exit. The loading classification for cleanouts in sidewalk areas or subject to vehicular traffic shall be heavy duty type.

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

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

2.6 FLOOR DRAINS

A. General Data: floor drain shall comply with ASME A112.6.3. A caulking flange, inside gasket, or hubless connection shall be provided for connection to cast iron pipe, screwed or no hub outlets for connection to steel pipe. The drain connection shall be bottom outlet. A membrane clamp and extensions shall be provided, if required, where installed in connection with waterproof membrane. Puncturing membrane other than for drain opening shall not be permitted. Double drainage pattern floor drains shall have integral seepage pan for embedding into floor construction, and weep holes to provide adequate drainage from pan to drain pipe. For drains not installed in connection with a waterproof membrane, a 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 C (FD-C) medium duty (non-traffic) floor drain shall comply with ASME A112.6.3. The type C floor drain shall have a cast iron body, double drainage pattern, clamping device, light duty nickel bronze adjustable strainer with round or square grate of 150 mm (6 inches) width or diameter minimum for toilet rooms, showers and kitchens.

C. Type D (FD-D) medium duty (non-traffic) floor drain shall comply with ASME A112.6.3. The type D floor drain shall have a cast iron body with flange for membrane type flooring, integral reversible clamping device, seepage openings and 175 mm (7 inch) diameter or square satin nickel bronze or satin bronze strainer with 100 mm (4 inch) flange for bottom of trench.

D. 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 nickel bronze 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. For traffic use, an extra heavy duty load classification ductile iron grate shall be provided.

E. Type M (FD-M) medium duty (non-traffic) floor drain shall comply with ASME A112.6.3. The type M floor drain shall have a cast iron body, nickel bronze adjustable funnel strainer and clamping device. Funnel strainer shall consist of a perforated floor-level square or round grate and funnel extension for indirect waste. Cut-out grate below funnel. Minimum dimensions as follows:
   1. Area of strainer and collar – 23,000 square mm (36 square inches).
   2. Height of funnel – 95 mm (3-3/4 inches).
   3. Diameter of lower portion of funnel – 50 mm (2 inches).
   4. Diameter of top portion of funnel – 100 mm (4 inches).
   5. Provide paper collars for construction purposes.

F. Type P (FD-P) medium duty (non-traffic) floor drain shall comply with ASME A112.6.3. The type P floor drain shall have a cast iron body, double drainage pattern, with all interior and exposed exterior surfaces provided with acid resistant enamel finish for sanitary areas. The type P floor drain shall have a clamping device, secured nickel bronze rim, an aluminum enameled finish sediment basket perforated with not less than 27,000 square mm (42 square inches) of free area and approximately 100 mm (4 inches) deep. The sediment bucket shall be provided with grips for easy handling. The loose-set, nickel bronze grate shall be approximately 7,700 square mm (12 square inches) and of sufficient strength to support pedestrian traffic. Ample space between body of drain and sediment basket shall be provided for free flow of waste liquids.

G. Type X (FD-X) floor drain shall comply with ASME A112.6.3. The type X floor drain shall be a chemical resistant floor drain and integral p-trap. Double drainage pattern floor drain shall have integral seepage pan for embedding in floor and weep holes to provide adequate drainage from pan to drainpipe. Floor drain shall be polypropylene, flame retardant, Schedule 40 or 80. An outlet of floor drain shall be suitable for properly joining a perforated or slotted floor level grate.

2.7 TRAPS

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

2.8 PRIMER VALVES AND TRAP SEAL PRIMER SYSTEMS

A. Trap Primer (TP-2): The trap seal primer valve shall be hydraulic, supply type with a pressure rating of 861 kPa (125 psig) and conforming to standard ASSE 1018.

1. The inlet and outlet connections shall be 15 mm or DN15 (NPS 1/2 inch)
2. The trap seal primer valve shall be fully automatic with an all brass or bronze body.
3. The trap seal primer valve shall be activated by a drop in building water pressure, no adjustment required.
4. The trap seal primer valve shall include a manifold when serving two, three, or four traps.
5. The manifold shall be omitted when serving only one trap.

2.9 PENETRATION SLEEVES

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

PART 3 - EXECUTION

3.1 PIPE INSTALLATION

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

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

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

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

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

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

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

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

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

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

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

L. Aboveground copper tubing shall be installed according to Copper Development Association’s (CDA) “Copper Tube Handbook”.

M. Aboveground PVC piping shall not be installed.

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

3.2 JOINT CONSTRUCTION

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

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

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

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

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

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

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

3.3 SPECIALTY PIPE FITTINGS

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

B. Dielectric fittings shall be installed at connections of dissimilar metal piping and tubing.

3.4 PIPE HANGERS, SUPPORTS AND ACCESSORIES

A. All piping shall be supported according to the International Plumbing Code (IPC), Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING, and these specifications. Where conflicts arise between these the code and Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING the most restrictive or the requirement that specifies supports with highest loading or shortest spacing shall apply.

B. Hangers, supports, rods, inserts and accessories used for pipe supports shall be painted according to Section 09 91 00, PAINTING. Electroplated copper hanger rods, hangers and accessories may be used with copper tubing.

C. Horizontal piping and tubing shall be supported within 300 mm (12 inches) of each fitting or coupling.

D. Horizontal cast iron piping shall be supported with the following maximum horizontal spacing and minimum hanger rod diameters:

1. 40 mm or DN40 to 50 mm or DN50 (NPS 1-1/2 inch to NPS 2 inch): 1500 mm (60 inches) with 10 mm (3/8 inch) rod.
2. 75 mm or DN75 (NPS 3 inch): 1500 mm (60 inches) with 15 mm (1/2 inch) rod.
3. 100 mm or DN100 to 125 mm or DN125 (NPS 4 inch to NPS 5 inch): 1500 mm (60 inches) with 18 mm (5/8 inch) rod.
4. 150 mm or DN150 to 200 mm or DN200 (NPS 6 inch to NPS 8 inch): 1500 mm (60 inches) with 20 mm (3/4 inch) rod.
5. 250 mm or DN250 to 300 mm or DN300 (NPS 10 inch to NPS 12 inch): 1500 mm (60 inch) with 23 mm (7/8 inch) rod.

E. Vertical piping and tubing shall be supported at the base, at each floor, and at intervals no greater than 4.6 m (15 feet).

F. In addition to the requirements in Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING, Floor, Wall and Ceiling Plates, Supports, Hangers shall have the following characteristics:

1. Solid or split unplated cast iron.
2. All plates shall be provided with set screws.
3. Height adjustable clevis type pipe hangers.
4. Adjustable floor rests and base flanges shall be steel.

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

G. Miscellaneous materials shall be provided as specified, required, directed or as noted in the contract documents for proper installation of hangers, supports and accessories. If the vertical distance exceeds 6.1 m (20 feet) for cast iron pipe additional support shall be provided in the center of that span. All necessary auxiliary steel shall be provided to provide that support.

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

I. Penetrations:

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

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

3.5 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 trenches are backfilled or fixtures are connected. A water test or air test shall be conducted, as directed.

1. If entire system is tested for a water test, tightly close all openings in pipes except highest opening, and fill system with water to point of overflow. If the waste system is tested in sections, tightly plug each opening except highest opening of section under test, fill each section with water and test with at least a 3 m (10 foot) head of water. In testing successive sections, test at least upper 3 m (10 feet) of next preceding section so that each joint or pipe except upper most 3 m (10 feet) of system has been submitted to a test of at least a 3 m (10 foot) head of water. Water shall be kept in the system, or in portion under test, for at least 15 minutes before inspection starts. System shall then be tight at all joints.
2. For an air test, an air pressure of 34 kPa (5 psig) gauge shall be maintained for at least 15 minutes without leakage. A force pump and mercury column gauge shall be used for the air test.
3. After installing all fixtures and equipment, open water supply so that all p-traps can be observed. For 15 minutes of operation, all p-traps shall be inspected for leaks and any leaks found shall be corrected.
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 shall be tested as part of a larger system.

3.7 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer’s technical representative for 4 hours to instruct each VA personnel responsible in operation and maintenance of the system.

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

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09-01-20

SECTION 22 13 23
SANITARY WASTE INTERCEPTORS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section pertains to concrete, polyethylene, and metal sanitary waste interceptors used for the removal of hair, oil, grease and sediment from waste streams for installations within the building envelope.

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

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

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

C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

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

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

F. Section 22 13 00, FACILITY SANITARY AND VENT PIPING.

1.3 APPLICABLE PUBLICATIONS

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

B. American Society of Mechanical Engineers (ASME):

A112.14.3-2018..........Hydromechanical Grease Interceptors

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

A48/A48M-2003(R2016)....Standards specification for Gray Iron Castings

A536-1984(R2019)e1......Standard Specification for Ductile Iron Castings

A615/A615M-2018e1.......Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement

C890-2019...............Standard Practice for Minimum Structural Design Loading for Monolithic or Sectional Precast Concrete Water and Wastewater Structures

C891-2019...............Standard Practice for Installation of Underground Precast Concrete Utility Structures

C913-2018...............Standard Specification for Precast Concrete Water and Wastewater Structures

C923-2018...............Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals

C1613-2017..............Standard Specification for Precast Concrete Grease Interceptor Tanks

D. International Code Council (ICC)

IPC-2018................International Plumbing Code

E. Plumbing and Drainage Institute (PDI):

PDI-G101-2017...........Testing and Rating Procedure for Hydro Mechanical Grease Interceptors

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 23, SANITARY WASTE INTERCEPTORS", with applicable paragraph identification.

C. Manufacturer's Literature and Data Including: For each type of interceptor indicated, the submittal shall include materials of fabrication, dimensions, rated capacities, retention capacities, operating characteristics, size and location of each pipe connection, furnished specialties, and accessories.

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

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

1. Include complete list indicating all components of the systems.
2. Include complete diagrams of the internal wiring for each item of equipment.
3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

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

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

1.5 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 https://www.biopreferred.gov.

1.6 AS-BUILT DOCUMENTATION

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

PART 2 - PRODUCTS

2.1 OIL INTERCEPTOR

A. Provide oil interceptor to intercept and collect free oil in a wastewater flow to prevent entry into the sanitary sewer system. Factory-fabricated, double wall steel body and steel/ gasketed lid; with settlement chamber and removable strainer; vents; and flow-control fitting on inlet. Outlet piping connection to be hub, hubless or threaded, unless otherwise indicated.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Interceptors shall be set level and plumb.

B. Install interceptor, including trapping, venting, and flow-control fittings according to the manufacture’s installation instructions and with recommended service clearances.

C. Install interceptor and grease/oil removal unit with cleanout immediately downstream from unit that do not have integral cleanout on the unit.

D. Interceptor covers shall be set flush with finished surface in pavements and the tops shall be traffic-rated. Set tops 75 mm (3 inches) above finished surface elsewhere unless otherwise indicated.

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

3.2 CONNECTIONS

A. Pipe installation requirements are specified in Section 22 13 00, FACILITY SANITARY AND VENT PIPING.

B. Piping connections shall be made between interceptor/grease/oil removal units and piping systems in accordance with manufacturer’s written guidelines.

3.3 WARNING TAPE

A. Warning tape shall be placed over ferrous piping.

B. Detectable warning tape shall be used over nonferrous pipe and over the edges of underground structures.

3.4 STARTUP AND TESTING

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

B. 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 cost or time to the Government.

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

3.5 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 4 hours to instruct VA Personnel responsible in operation and maintenance of the system.

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

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SECTION 22 14 00
FACILITY STORM DRAINAGE

PART 1 - GENERAL

1.1 DESCRIPTION

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

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

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

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

C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

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

E. Section 07 92 00, JOINT SEALANTS.

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

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

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

kmJ. Section 22 07 11, PLUMBING INSULATION.

I. 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):

A112.6.4-2003 (R2012) ..Roof, Deck, and Balcony Drains

A13.1-2007 (R2013)......Scheme for Identification of Piping Systems

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

B16.3-2011..............Malleable Iron Threaded Fittings: Classes 150 and 300

B16.9-2012..............Factory-Made Wrought Buttwelding Fittings

B16.11-2011.............Forged Fittings, Socket-Welding and Threaded

B16.12-2009 (R2014).....Cast Iron Threaded Drainage Fittings

B16.15-2013.............Cast Copper Alloy Threaded Fittings: Classes 125 and 250

B16.18-2012.............Cast Copper Alloy Solder-Joint Pressure Fittings

B16.22-2013.............Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings

B16.23-2011.............Cast Copper Alloy Solder Joint Drainage Fittings - DWV

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

C. American Society of Sanitary Engineering (ASSE)

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

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

A47/A47M-1999 (R2014)...Standard Specification for Ferritic Malleable Iron Castings

A53/A53M-2012...........Standard Specification for Pipe, Steel, Black And Hot-Dipped, Zinc-coated Welded and Seamless

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

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

A536-1984(R2014)........Standard Specification for Ductile Iron Castings

A733-2013...............Standard Specification for Welded and Seamless Carbon Steel and Austenitic Stainless Steel Pipe Nipples

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

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

B61-2008 (R2013)........Standard Specification for Steam or Valve Bronze Castings

B62-2009................Standard Specification for Composition Bronze or Ounce Metal Castings

B75/B75M-2011...........Standard Specification for Seamless Copper Tube

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

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

B584-2014...............Standard Specification for Copper Alloy Sand Castings for General Applications

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

B828-2002 (R2010).......Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings

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

C564-2014...............Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings

C1173-2010 (R2014)......Standard Specification for Flexible Transition Couplings for Underground Piping Systems

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

D2321-2014e1............Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications

D4101-2014..............Standard Specification for Polypropylene Injection and Extrusion Materials

F477-2014...............Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe

F1545-2015..............Standard Specification for Plastic-Lined Ferrous Metal Pipe, Fittings, and Flanges

E. American Welding Society (AWS):

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

F. Copper Development Association (CDA):

A4015-2011..............Copper Tube Handbook

G. Cast Iron Soil Pipe Institute (CISPI):

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

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

H. International Code Council (ICC):

IPC-2012................International Plumbing Code

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

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

1.4 SUBMITTALS

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

B. Information and material submitted under this section shall be marked “SUBMITTED UNDER SECTION 22 14 00, FACILITY STORM DRAINAGE”, with applicable paragraph identification.

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

1. Pipe and Fittings.
2. Specialty Pipe Fittings.
3. Cleanouts.
4. Roof Drains.

5. Downspout Nozzles.
7. Sleeve Flashing Devices.

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

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

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

1.5 QUALITY ASSURANCE

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

1.6 AS-BUILT DOCUMENTATION

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

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

C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. As-built drawings are to be provided, and a copy of them in Auto-CAD provided on compact disk or DVD. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the ‘third party testing company’ requirement.

D. Certification documentation shall be provided to COR 10 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and certification that all results of tests were within limits specified.

PART 2 - PRODUCTS

2.1 STORM WATER DRAIN PIPING

A. Cast Iron Storm Pipe and Fittings:

1. Cast iron storm pipe and fittings shall be used for the following applications:
   a. Pipe buried in or in contact with earth.
   b. Extension of pipe to a distance of approximately 1500 mm (5 feet) outside of building walls.
   c. Interior storm piping above grade.
   d. All mechanical equipment rooms or other areas containing mechanical air handling equipment.
2. The cast iron storm pipe shall be bell and spigot, or hubless (plain end or no-hub) as required by selected jointing method.
3. The material for all pipe and fittings shall be cast iron soil pipe and fittings and shall conform to the requirements of CISPI 301, ASTM A888, or ASTM A74.
4. Joints for hubless pipe and fittings shall conform to the manufacturer’s installation instructions. Couplings for hubless joints shall conform to CISPI 310. Joints for hub and spigot pipe shall be installed with compression gaskets conforming to the requirements of ASTM C564.

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

C. Roof drain piping and body of drain in locations where the outdoor conditions are subject to freezing shall be insulated.

2.2 PUMPED DRAIN PIPING

A. Pumped drain piping 75 mm (3 inches) and less shall be copper tube conforming to ASTM B88, type K or L.

B. Pumped drain pipe fittings shall comply with the following:
   1. Wrought copper or bronze castings for use with copper tube conforming to ASME B16.18 and B16.22.
   2. Unions, for use with copper tube up to 50 mm (2 inches) shall be cast with bronze, conforming to ASME B16.18 and ASTM B584 with solder or braze joints.
   3. Grooved fittings, for use with copper tube 65 mm to 100 mm (2-1/2 to 4 inch) shall be wrought copper conforming to ASTM B75/B75M, alloy C12200, 125 to 150 mm (5 to 6 inch) bronze castings conforming to ASTM B584.
   4. Mechanical grooved couplings shall have a ductile iron housing conforming to ASTM A536 (Grade 65-45-12) elastomer gasket suitable for potable water service and process temperature and steel track head bolts conforming to ASTM A183, housing shall be coated with colored alkyd enamel paint.

C. Adapters shall be provided for joining pipe with different end connections.

D. The solder shall be lead free using a water flushable, non-corrosive flux conforming to ASTM B32.

E. Dielectric fittings and specialties shall be provided when joining pipe of dissimilar metals.

2.3 SPECIALTY PIPE FITTINGS

A. Transition pipe couplings shall join piping with small differences in outside diameters or be of different materials. End connections shall be of the same size and compatible with the pipes being joined. The transition coupling shall be unshielded, elastomeric, sleeve type reducing, or transition pattern conforming with ASTM C1173 and include shear ring and corrosion resistant metal tension band and tightening mechanism on each end. The transition coupling sleeve coupling shall be of the following material:

1. For cast iron soil pipes, the sleeve material shall be rubber conforming to ASTM C564.
2. Dissimilar pipes, the sleeve material shall be PVC conforming to ASTM D5926, or other material compatible with the pipe materials being joined.

B. Dielectric fittings shall conform to ASSE 1079 with a pressure rating of 1035 kPa (150 psig) at a minimum temperature of 82 degrees C (180 degrees F). The end connection shall be solder joint copper alloy and threaded ferrous.

C. Dielectric flanges shall conform to ASSE 1079 with a pressure rating of 1200 kPa (175 psig). The flange shall be a factory fabricated, bolted, companion flange assembly. The end connection shall be threaded or solder-joint copper alloy and threaded ferrous.

D. 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.

E. Dielectric nipples shall be electroplated steel and shall conform with ASTM F1545 with a pressure ratings of 2070 kPa (300 psig) at 107 degrees C (225 degrees F). The end connection shall be male threaded. The lining shall be inert and noncorrosive propylene. Bio-based materials shall be utilized when possible.

2.4 CLEANOUTS

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

B. Floor cleanouts shall be gray iron housing with clamping device and round, secured, scoriated, gray iron cover conforming to ASME A112.36.2M. A gray iron ferrule with hubless, socket, inside caulk or spigot connection and counter sunk, taper-thread, brass or bronze closure plug shall be included. The frame and cover material and finish shall be nickel-bronze copper alloy with a square shape. The cleanout shall be vertically adjustable for a minimum of 50 mm (2 inches). When a waterproof membrane is used in the floor system, clamping collars shall be provided on the cleanouts. Cleanouts shall consist of wye fittings and eighth bends with brass or bronze screw plugs. Cleanouts in the resilient tile floors, quarry tile and ceramic tile floors shall be provided with square top covers recessed for tile insertion. In the carpeted areas, carpet cleanout markers shall be provided. Two way cleanouts shall be provided where indicated on the drawings and at each building exit. The loading classification for cleanouts in sidewalk areas or subject to vehicular traffic shall be heavy duty.

C. Cleanouts shall be provided at or near the base of the vertical stacks with the cleanout plug located approximately 600 mm (24 inches) above the floor. The cleanouts shall be extended to the wall access cover. Cleanout shall consist of sanitary tees. Nickel bronze square frame and stainless steel cover with minimum opening of 150 mm by 150 mm (6 inch by 6 inch) shall be provided at each wall cleanout.

D. In horizontal runs above grade, cleanouts shall consist of cast brass tapered screw plug in fitting or caulked/no hub cast iron ferrule. Plain end (no-hub) piping in interstitial space or above ceiling may use plain end (no-hub) blind plug and clamp.

2.5 ROOF DRAINS AND CONNECTIONS

A. Roof Drains: Roof Drains (RD) shall be cast iron with clamping device for making watertight connection and shall conform with ASME A112.6.4. Free openings through strainer shall be twice area of drain outlet. For roof drains not installed in connection with a waterproof membrane, a soft copper membrane shall be provided 300 mm (12 inches) in diameter greater than outside diameter of drain collar. An integral gravel stop shall be provided for drains installed on roofs having built up roofing covered with gravel or slag. Integral no-hub, soil pipe gasket or threaded outlet connection shall be provided.

1. Flat Roofs: The roof drain shall have a beehive or dome shaped strainer with integral flange not less than 300 mm (12 inches) in diameter. For an insulated roof, a roof drain with an adjustable drainage collar shall be provided, which can be raised or lowered to meet required insulation heights, sump receiver and deck clamp. The bottom section shall serve as roof drain during construction before insulation is installed.

B. Downspout Nozzle: The downspout nozzle fitting shall be of brass, unfinished, with internal pipe thread for connection to downspout.

2.6 WATERPROOFING

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

PART 3 - EXECUTION

3.1 PIPE INSTALLATION

A. The pipe installation shall comply with the requirements of the IPC and these specifications.

B. Branch piping shall be installed from the piping system and connect to all drains and outlets.

C. Pipe shall be round and straight. Cutting shall be done with proper tools. Pipe, except for glass, shall be reamed to remove burrs and a clean smooth finish restored to full pipe inside diameter.

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

E. The piping shall be installed above accessible ceilings to allow for ceiling panel removal.

F. Unless otherwise stated on the documents, minimum horizontal slope shall be one inch for every 2.44 m (8 feet) (1 percent slope) of pipe length.

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

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

I. Changes in direction for storm drainage piping shall be made using appropriate branches, bends and long sweep bends. Sanitary tees and short sweep ¼ bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Long turn double wye branch and 1/8 bend fittings shall be used if two drains are installed back to back or side by side with common drain pipe. Do not change direction of flow more than 90 degrees. Proper size of standard increaser and reducers shall be used if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

J. Buried storm drainage piping shall be laid beginning at the low point of each system. Piping shall be installed true to grades and alignment indicated with unbroken continuity of invert. Hub ends shall be placed upstream. Required gaskets shall be installed according to manufacturer’s written instruction for use of lubricants, cements, and other installation requirements. Bio-based materials shall be utilized when possible.

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

L. Aboveground copper tubing shall be installed according to CDA A4015.

3.2 JOINT CONSTRUCTION

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

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

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

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

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is required by the pipe service
2. Pipe sections with damaged threads shall be replaced with new undamaged sections of pipe at no additional time or cost to Government.

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

3.3 SPECIALTY PIPE FITTINGS

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

B. Dielectric fittings shall be installed at connections of dissimilar metal piping and tubing.

3.4 PIPE HANGERS, SUPPORTS AND ACCESSORIES

A. All piping shall be supported according to the IPC, Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING, and these specifications.

B. Hangers, supports, rods, inserts and accessories used for Pipe supports shall be shop coated with zinc Chromate primer paint. Electroplated copper hanger rods, hangers and accessories may be used with copper tubing.

C. Horizontal piping and tubing shall be supported within 300 mm (12 inches) of each fitting or coupling.

D. Horizontal cast iron piping shall be supported with the following maximum horizontal spacing and minimum hanger rod diameters:

1. NPS 1-1/2 to NPS 2 (DN 40 to DN 50): 1500 mm (60 inches) with 10 mm (3/8 inch) rod.
2. NPS 3 (DN 80): 1500 mm (60 inches) with 15 mm (1/2 inch) rod.
3. NPS 4 to NPS 5 (DN 100 to DN 125): 1500 mm (60 inches) with 18 mm (5/8 inch) rod.
4. NPS 6 to NPS 8 (DN 150 to DN 200): 1500 mm (60 inches) with 20 mm (3/4 inch) rod.
5. NPS 10 to NPS 12 (DN 250 to DN 300): 1500 mm (60 inches) with 23 mm (7/8 inch) rod.

E. Vertical piping and tubing shall be supported at the base, at each floor, and at intervals no greater than 4.6 m (15 feet).

F. In addition to the requirements in Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING, floor, wall and ceiling plates shall have the following characteristics:

1. Solid or split unplated cast iron.
2. All plates shall be provided with set screws.
3. Height adjustable clevis type pipe hangers.
4. Adjustable Floor Rests and Base Flanges shall be steel.
5. Hanger Rods shall be low carbon steel, fully threaded or threaded at each end with two removable nuts at each end for positioning rod and hanger and locking each in place.
6. Riser Clamps shall be malleable iron or steel.
7. Roller shall be cast iron.
8. Hangers and supports utilized with insulated pipe and tubing shall have 180 degree (minimum) metal protection shield centered on and welded to the hanger and support. The shield shall be 100 mm (4 inches) in length and be 1.6 mm (16 gage) steel. The shield shall be sized for the insulation.

G. Miscellaneous materials shall be provided as specified, required, directed or as noted on the drawings for proper installation of hangers, supports and accessories. If the vertical distance exceeds 6.1 m (20 feet) for cast iron pipe additional support shall be provided in the center of that span. All necessary auxiliary steel shall be provided to provide that support.

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

I. Penetrations:

1. Fire Stopping: Where pipes pass through fire partitions, fire walls, smoke partitions, or floors, a fire stop shall be installed that provides an effective barrier against the spread of fire, smoke and gases as specified in Section 07 84 00, FIRESTOPPING. Clearances between raceways and openings shall be completely filled and sealed with the fire stopping materials.

2. Water proofing: At floor penetrations, Clearances around the pipe shall be completely sealed and made watertight with sealant as specified in Section 07 92 00, JOINT SEALANTS. Bio-based materials shall be utilized when possible.

3.5 INSULATION

A. Insulate horizontal sections and 600 mm (2 feet) past changes of direction to vertical sections for interior section of roof drains. Install insulation in accordance with the requirements of Section 22 07 11, PLUMBING INSULATION.

3.6 TESTS

A. Storm sewer system shall be tested either in its entirety or in sections.

B. Storm Water Drain tests shall be conducted before trenches are backfilled or fixtures are connected. A water test or air test shall be conducted, as directed.

1. If entire system is tested with water, tightly close all openings in pipes except the highest opening, and fill system with water to point of overflow. If system is tested in sections, tightly plug each opening except highest opening of section under test, fill each section with water and test with at least a 3 m (10 foot) head of water. In testing successive sections, test at least upper 3 m (10 feet) of next preceding section so that each joint or pipe except upper most 3 m (10 feet) of system has been submitted to a test of at least a 3 m (10 foot) head of water. Water shall be kept in the system, or in portion under test, for at least 15 minutes before inspection starts. System shall then be tight at all joints.

2. For an air test, an air pressure of 34 kPa (5 psig) gage shall be maintained for at least 15 minutes without leakage. A force pump and mercury column gage shall be used for the test.

3. Final Tests: While either one of the following tests may be used, Contractor shall check with VA as to which test will be performed.

   a. Smoke Test: After fixtures are permanently connected and traps are filled with water, fill entire drainage and vent systems with smoke under pressure of 0.25 kPa (1 inch of water) with a smoke machine. **Chemical smoke is prohibited.**

b. Peppermint Test: Introduce .06 liters (2 ounces) of peppermint into each line or stack.

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

3.7 COMMISSIONING

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

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

3.8 DEMONSTRATION AND TRAINING

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

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

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SECTION 22 14 29
SUMP PUMPS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Sump pumps. See schedule on Drawings for pump capacity and head.

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

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

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

C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

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

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 23, GENERAL-DUTY VALVES FOR PLUMBING PIPING

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

I. 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 National Standard Institute (ANSI)/Hydraulic Institute (HI):

1.1-1.2-2014...........Rotodynamic Centrifugal Pumps for Nomenclature and Definitions

1.3-2013...............Rotodynamic Centrifugal Pumps for Design and Application

1.4-2014...............Rotodynamic Centrifugal Pumps for Manuals Describing Installation, Operation, and Maintenance

C. ASTM International (ASTM):

A48/A48M-2003 (R2012)...Standard Specification for Gray Iron Castings

A532/A532M-2010 (R2014).Standard Specification for Abrasion-Resistant Cast Irons

B584-2014...............Standard Specification for Copper Alloy Sand Castings for General Applications

D. National Electrical Manufacturers Association (NEMA):

ICS 6-1993 (R2001, R2006) Industrial Control and Systems: Enclosures

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

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

508-1999 (R2013)........Standards 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 14 29, SUMP PUMPS”, with applicable paragraph identification.

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

1. Pump:
   a. Manufacturer and model.
   b. Operating speed (rpm).
   c. Capacity.
   d. Characteristic performance curves.
2. Electric Motor:
   a. Manufacturer, frame and type .
   b. Speed.
   c. Current Characteristics and W (HP).
   d. Efficiency.
3. Control panel.
4. Sensors.

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

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

1. Include complete list which indicates all components of the system.
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, and troubleshooting.

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

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

1.5 QUALITY ASSURANCE

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

1.6 AS-BUILT DOCUMENTATION

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

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

C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. As-built drawings are to be provided, and a copy of them in Auto-CADD 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 a certification that all results of tests were within limits specified.

PART 2 - PRODUCTS

2.1 SUMP PUMP

A. Centrifugal, vertical, submersible pump and motor, designed for 60 or 82 degrees C (140 or 180 degrees F) maximum water service. Driver shall be electric motor. Support shall be rigid type. Provide perforated, suction strainer. Systems may include one, two, or more pumps with alternator as required by Contract Documents. Pumps shall be capable of continuous duty cycle.

1. Pump housings may be cast iron, bronze, aluminum or stainless steel. Cast iron and aluminum housings for submersible pumps shall be epoxy coated. Bio-based materials shall be utilized when possible.

B. Impeller: Statically and dynamically balanced, keyed and secured to shaft, bronze ASTM B584.

C. Shaft: Stainless steel or other approved corrosion-resisting metal.

D. Bearings: As required to hold shaft alignment, anti-friction type for thrust permanently lubricated. Bio-based materials shall be utilized when possible.

E. Seal: Mechanical.

F. Motor: Maximum 40 degrees C (104 degrees F) ambient temperature rise above the maximum fluid temperature being pumped , drip-proof hermitically sealed, lifting eye, capacitor start type, voltage and phase as shown in schedule on Electrical drawings conforming to NEMA Type 4X . Size the motor capacity to operate pump without overloading the motor at any point on the pump curve. Refer to Section 22 05 12, GENERAL MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT.

G. Starting Switch: Manually-operated, tumbler type, as specified in Section 26 29 11, MOTOR CONTROLLERS.

H. Automatic Control and Level Alarm: Furnish a control panel in a NEMA 1 enclosure for indoors or in a NEMA 4X enclosure for outdoors. The controls shall be suitable for operation with the electrical characteristics listed on the Electrical drawings. The control panel shall have a level control system with switches to start and stop pumps automatically, and to activate a high water alarm. The level control system shall include sensors in the sump that detect the level of the liquid. The pump is also connected to a control which has the ability to prevent oil from being pumped. The same unit shall activate an alarm when oil is detected. The sensors may be float type switches, ultrasonic level sensors, or transducers. The high water alarm shall have a red beacon light at the control panel and a buzzer, horn, or bell. The alarm shall have a silencing switch. Provide auxiliary contacts for remote communication with, and alarm monitoring to, the BAS using a BACnet compatible open-protocol type interface to DDC Controls System.

1. The circuitry of the control panel shall include:
    a. Power switch to turn on/off the automatic control mechanism
    b. HOA switches to manually override automatic control mechanism
    c. Run lights to indicate when pumps are powered up
    d. Level status lights to indicate when water in sump has reached the predetermined on/off and alarm levels
    e. Magnetic motor contactors
    f. Disconnect/breaker for each pump
    g. Automatic motor overload protection
    h. Wiring terminal block
    i. Dead front
    j. Auxiliary contacts
    k. Control circuit protection
    l. Fused control step down transformer

2. Sensors that detect the level of water in the sump shall be so arranged as to allow the accumulation of enough volume of liquid below the normal on-level that the pump will run for a minimum cycle time as recommended by the pump manufacturer. Sensors shall be located to activate the alarm adequately before the water level rises to the inlet pipe.
3. Provide two separate power supplies to the control panel, one for the control/alarm circuitry and one for power to the pump motors. Each power supply is to be fed from its own breaker so that if a pump overload trips a breaker, the alarm system shall still function. Each power supply is to be wired in its own conduit.
4. Wiring from the sump to the control panel shall have separate conduits for the pump power and for the sensor switches. All conduits are to be sealed at the basin and at the control panel to prevent the intrusion of moisture and of flammable and/or corrosive gases.

I. Sump: Concrete basin with gas tight covers. Cover shall have 275 mm by 381 mm (11 inch by 15 inch) manhole with bolted cover, vent connection, openings for pumps and controls. Sump shall be sized to allow an adequate volume of water to accumulate for a minimum one minute cycle of pump operation.

J. Provide a check and ball valve in the discharge of each pump. Refer to Section 22 05 23, GENERAL-DUTY VALVES FOR PLUMBING PIPING.

K. Removal/Disconnect System: In a system utilizing a submersible pump, where sump depth, pump size, or other conditions make removal of the pump unusually difficult or unsafe, a manufacturer’s removal/disconnect system shall be provided. The system shall consist of a discharge fitting mounted on vertical guide rails attached to the sump or quick connect pipe fitting connection to piping. The pump shall be fitted with an adapter fitting that easily connects to/disconnects from the discharge fitting as the pump is raised from or lowered into the sump. The discharge piping shall connect to the discharge fitting so that it is disconnected without workers entering the pit. Where the sump depth is greater than five feet or other conditions exist to make the removal of the pump difficult or hazardous, the system shall include a rail guided quick disconnect apparatus to allow the pump to be pulled up out of the sump.

PART 3 - EXECUTION

3.1 STARTUP AND TESTING

A. Pump installation to comply with ANSI/HI 1.4 for sump pumps.

B. Leak Test: Charge piping system and test for leaks. Test until there are no leaks. Make tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.

C. The tests shall include system capacity and all control and alarm functions.

D. When any defects are detected, correct defects and repeat test.

E. The CxA will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the COR and CxA. Contractor shall provide a minimum of 10 working days prior to startup and testing.

3.2 COMMISSIONING

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

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

3.3 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer’s technical representative for four hours to instruct VA Personnel in operation and maintenance of units.

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

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SECTION 22 15 00
GENERAL SERVICE COMPRESSED-AIR SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section describes the requirements for NFPA 99 Category 4 compressed air systems for non-medical air piping materials, including compressors, electric motors and starters, receiver, all necessary piping, fittings, valves, gauges, switches and all necessary accessories, connections and equipment. NFPA 99 Category 4 systems are non-medical systems of 689 kPa (100 psig) or less in which failure of equipment would have no impact on patient care.

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

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

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

C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

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

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

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

G. Section 22 05 19, METERS AND GAGES FOR PLUMBING PIPING: Exposed piping and gauges.

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

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

1.3 APPLICABLE PUBLICATIONS

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

B. American Society of Civil Engineers (ASCE):

7-2016..................Minimum Design Loads and Associated Criteria or Buildings and Other Structures

C. American Society of Mechanical Engineers (ASME):

A13.1-2015..............Scheme for the Identification of Piping Systems

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

B16.3-2016.............Malleable Iron Threaded Fittings: Classes 150 and 300

B16.39-2019............Malleable Iron Threaded Pipe Unions: Classes 150, 250, and 300

B16.5-2017.............Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch

B16.9-2018.............Factory-Made Wrought Buttwelding Fittings

B16.21-2016............Nonmetallic Flat Gaskets for Pipe Flanges

Bl6.22-2018............Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings

B16.24-2016............Cast Copper Alloy Pipe Flanges, Flanged Fittings, and Valves: 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)

B40.100-2013...........Pressure Gauges and Gauge Attachments

ASME Boiler and Pressure Vessel Code -

BPVC Section VIII-1-2019 Rules for Construction of Pressure Vessels, Division 1

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

A47/A47M-1999(2018)e1...Standard Specification for Ferritic Malleable Iron Castings

A53/A53M-2018..........Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

A106/A106M-2019a........Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service

A126-2004(R2019)........Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings

A135/A135M-2019.........Standard Specification for Electric-Resistance Welded Steel Pipe

A536-1984(2019)e1.......Standard Specification for Ductile Iron Castings

A733-2016...............Standard Specification for Welded and Seamless Carbon Steel and Austenitic Stainless Steel Nipples

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

B61-2015................Standard Specification for Steam or Valve Bronze Castings

B62-2017................Standard Specification for Composition Bronze or Ounce Metal Castings

B88-2016................Standard Specification for Seamless Copper Water Tube

B584-2014...............Standard Specification for Copper Alloy Sand Castings for General Applications

B813-2016...............Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube

B819-2019...............Standard Specification for Seamless Copper Tube for Medical Gas Systems

E. American Water Works Association (AWWA):

C606-2015...............Grooved and Shouldered Joints

F. American Welding Society (AWS):

A5.8M/A5.8-2019.........Specification for Filler Metals for Brazing and Braze Welding

G. International Code Council (ICC):

IPC-2018................International Plumbing Code

H. Manufacturer Standardization of the Valve and Fittings Industry, Inc (MSS):

SP-70-2011..............Gray Iron Gate Valves, Flanged and Threaded Ends

SP-71-2018..............Gray Iron Swing Check Valves, Flanged and Threaded Ends

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

SP-80-2019..............Bronze Gate, Globe, Angle, and Check Valves

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

SP-123-2018.............Non-Ferrous Threaded and Solder-Joint Unions for Use with Copper Water Tube

I. National Electrical Manufacturers Association (NEMA):

ICS 6-1993(R2016).......Industrial Control and Systems: Enclosures

J. National Fire Protection Association (NFPA):

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

99-2018.................Health Care Facilities Code

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

213-2019................ANSI/CAN/UL Standard for Rubber Gasketed Fittings for Fire-Protective Services

508-2018................Standard for Industrial Control Equipment

1.4 SUBMITTALS

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

B. Information and material submitted under this section shall be marked “SUBMITTED UNDER SECTION 22 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. Underground Piping
3. Supporting Elements
4. Valves
5. Pressure Gauges
6. Air Pressure Reducing and Regulating Valves
7. Automatic Drain Valves
8. Filter Capacity and Operating Characteristics
9. Vibration Isolation
10. Quick Couplings
11. Hose Assemblies
12. 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
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. For seismic restraint design the following shall be submitted:
1. Dimensioned drawings of equipment identifying center of gravity and location and description of seismic mounting and anchorage systems.

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

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

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

1.5 QUALITY ASSURANCE

A. The Contractor shall obtain the services of a qualified engineer or technician from the compressor manufacturer to review final installation and supervise startup 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 https://www.biopreferred.gov.

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

1.6 AS-BUILT DOCUMENTATION

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

PART 2 - PRODUCTS

2.1 PIPES, TUBES AND FITTINGS

A. Pipe for general service compressed air system shall be drawn temper, Type "K" or "L" 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.

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

F. Schedule 40, Steel Pipe: ASTM A53/A53M, Type E or S, Grade B, black or hot-dip zinc coated with ends threaded according to ASME B1.20.1.

1. Steel Nipples: ASTM A733, made of ASTM A53/A53M or ASTM A106/A106M, Schedule 40, galvanized seamless steel pipe. Include ends matching joining method.
2. Malleable-Iron Fittings: ASME B16.3, Class 150 or 300, threaded.
3. Malleable-Iron Unions: ASME B16.39, Class 150 or 300, threaded.
4. Steel Flanges: ASME B16.5, Class 150 or 300, carbon steel, threaded.
5. Wrought-Steel Butt-Welding Fittings: ASME B16.9, Schedule 40.
6. Steel Flanges: ASME B16.5, Class 150 or 300, carbon steel.
7. Grooved-End Fittings and Couplings:
   a. Grooved-End Fittings: ASTM A47/A47M, malleable-iron castings or ASTM A536, ductile-iron casting; with grooves according to AWWA C606 and dimensions matching steel pipe.
   b. Couplings: AWWA C606 or UL 213, for steel-pipe dimensions and rated for 2070 kPa (300 psig) minimum working pressure. Include ferrous housing sections, gasket suitable for compressed air, and bolts and nuts. Provide EDPM gaskets for oil-free compressed air. Provide NBR gaskets if compressed air contains oil or oil vapor.

G. Schedule 5, Steel Pipe: ASTM A135/A135M, carbon steel with plain ends and zinc-plated finish.

1. Pressure-Seal Fittings: Listed and labeled by a qualified testing agency and FMG-approved, carbon-steel, pressure-seal housing with O-ring end seals suitable for compressed-air piping and rated for 2070 kPa (300 psig) minimum working pressure. Provide EDPM seals for oil-free compressed air. Provide NBR seals if compressed air contains oil or oil vapor.

H. Transition Couplings for Metal Piping: Metal coupling or other manufactured fitting same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.

I. Pipe identification shall comply with ASME A13.1. Pipe identification labels shall be located as follows:

1. At intervals of not more than 6.1 m (20 feet).
2. At least visible once in or above every room.
3. On both sides of walls or partitions penetrated by the piping.
4. At least once in every story height traversed by risers.

2.2 VALVES

A. Ball:

1. Ball valves 75 mm or DN80 (NPS 3 inches) and smaller shall be full port, two-piece or three-piece ball valve conforming to MSS SP-110. The ball valve shall have a SWP rating of 1034 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.
2. Ball valves 100 mm or DN100 (NPS 4 inches) and larger shall be flanged, Class 150, full port steel ball valve conforming to MSS SP-72. The body shall be split design. The CWP rating shall be 1964 kPa (285 psig). The seals shall be PTFE or TFE. Ball and stem shall be stainless-steel.

B. Check:

1. Check valves smaller than 100 mm or DN100 (NPS 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. Check valves 100 mm or DN100 (NPS 4 inches) and larger 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.

2.3 DIELECTRIC FITTINGS

A. Fittings joining copper alloy and ferrous materials shall be isolated.

B. Dielectric unions shall be factory-fabricated union assemblies, rated at 1724 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 63 mm (NPS 2-1/2 inches) and larger shall be flanged steel nipple.

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) 1724 kPa (250 psig) minimum.

2.5 SPECIALTIES

A. Pressure Gauges: Pressure gauges 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 B40.100, pressure gauge, single, size 114 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", 38 mm (1-1/2 inch) diameter gauge with dial range 1 to 689 kPa (1 to 100 psig) for air service.

B. Air Pressure Regulating Valves:

1. Air pressure regulating valves under 75 mm or DN80 (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.
2. Air pressure regulators 75 mm or DN80 (NPS 3 inches)and larger shall be pilot operated, bronze body, direct acting, spring loaded manual pressure setting adjustment and rated for 1724 kPa (250 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 include mounting brackets for wall mount application.

F. Air line lubricators shall come with a drip chamber and sight dome for observing oil drop entering air stream. The air line lubricator shall have oil feed adjustment screw and quick release collar for easy bowl removal. The Air line lubricators shall include mounting brackets for wall mount application. Lubricators shall be suitable for 1380 kPa (200 psig) at 71 degrees C (160 degrees F).

2.6 QUICK CONNECT COUPLINGS

A. The quick connect coupling assemblies shall have a locking mechanism constructed to permit one-handed feature for quick connection and disconnection of compressed air hose and equipment. Furnish complete keyed indexing noninterchangeable coupling to prevent connection to medical compressed-air pressure outlets.

B. Automatic shutoff quick couplings shall be straight through brass body with O-ring or gasket seal and stainless-steel or nickel plated steel operating parts. The automatic shutoff quick connect coupling shall consist of socket or plug ends with one way valve and with barbed outlet or threaded hose fittings for attaching hose.

C. Valve less quick couplings shall be straight through brass body with O-ring or gasket seal and stainless-steel or nickel plated steel operating parts. The valve less quick connect coupling shall consist of socket or plug ends and with barbed outlet or threaded hose fittings for attaching hose.

2.7 HOSE ASSEMBLIES

A. Hose, clamps, couplings, splicers shall be suitable for compressed air service of nominal diameter indicated and rated for 2070 kPa (300 psig) minimum working pressure.

B. The hose shall be reinforced double wire braid, chloroprene reinforced covered hose.

C. Hose clamps shall be stainless-steel.

D. Hose couplings shall be two-piece straight through, threaded brass or stainless-steel O-ring or gasket seal swivel coupling with barbed ends for connecting two sections of hose.

E. Hose splicers shall be one piece, straight through brass or stainless-steel fitting with barbed ends.

2.8 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 01 45 00 QUALITY CONTROL, to design compressed-air equipment mounting.

B. Seismic Performance: Compressed-air equipment shall withstand the effects of earthquake motions determined according to ASCE/SEI 7 Insert requirement as specified in Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

   1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event.”

2.9 GENERAL REQUIREMENTS FOR PACKAGED AIR COMPRESSORS AND RECEIVERS

A. System Design: Factory assembled automatic control system with load control and protection functions, mounted, -wired, -piped, and -tested; electric-motor-driven; air-cooled; continuous-duty air compressors and receivers that deliver air of quality equal to intake air

B. Control Panels: Shall comply with NEMA ICS 6, Type 12 and UL 508 labeled.

   1. Enclosure: NEMA ICS 6, Type 12 control panel unless otherwise indicated.

2. Motor Controllers: Full-voltage, combination magnetic type with undervoltage protective feature and motor-circuit-protector-type disconnecting means and short-circuit protective device.
3. Control Voltage: 120-V ac or less, using integrated control power transformer.
4. Motor Overload Protection: Overload relay in each phase.
5. Starting Devices: Hands-off-automatic selector switch in cover of control panel, plus pilot device for automatic control.
6. Automatic control switches to alternate lead-lag compressors for duplex sequence lead-lag compressors for multiplex compressors.
7. Instrumentation: Include discharge-air pressure gauge, air-filter maintenance indicator, hour meter, compressor discharge-air and coolant temperature gauges, and control transformer.
8. Alarm Signal Device: For connection to alarm system to indicate when backup air compressor is operating.

C. Air Receiver: Vertical air receiver, Steel tank constructed according to ASME BPVC Section VIII, Division 1.
1. Rated for minimum 1034 kPa (150 psig) design pressure and bearing appropriate code symbols. Including a sight gauge glass as well as a timed automatic solenoid drain valve.
2. Interior Finish: Corrosion-resistant coating.
3. Accessories: Include safety valve, pressure gauge, drain, pressure-reducing valve and three valve bypass on supply.

D. Mounting Frame: Fabricate mounting and attachment to pressure vessel with reinforcement strong enough to resist packaged equipment movement during a seismic event when base is anchored to building structure.

2.10 OIL-FREE, RECIPROCATING AIR COMPRESSORS

A. Compressor(s): Oil-free, reciprocating-piston type with nonlubricated compression chamber, lubricated crankcase, and of construction that prohibits oil from entering compression chamber.
1. Submerged gear-type oil pump.
2. Oil filter.
3. Combined high discharge-air temperature and low lubrication-oil pressure switch.
4. Belt guard totally enclosing pulleys and belts.

2.11 PRESSURE REGULATORS

A. For 689 kPa (100 psig) regulator, provide duplex in parallel, valve for maintenance shut-down without service interruption. For additional pressures, locate regulators remote from compressor near point of use, and provide with isolation valves and valve bypass.

1. For systems 5 L/s (10 SCFM) and below: Brass or bronze body and trim, reduced pressure range 170 to 850 kPa (25 to 123 psig) adjustable, spring type, diaphragm operated, relieving. Delivered pressure shall vary not more than 1.0 kPa (0.15 psig) for each 10 kPa (1.5 psig) variation in inlet pressure.

2.12 INLET-AIR FILTERS

A. Description: Combination inlet-air filter-silencer, suitable for remote installation, for each air compressor.

1. Construction: Weatherproof housing for replaceable, dry-type filter element, with silencer tubes or other method of sound reduction.
2. Capacity: Match capacity of air compressor, with filter having collection efficiency of 99 percent retention of particles larger than 10 micrometers.

B. Description: Combination inlet-air filter-silencer, suitable for remote installation, for multiple air compressors.

1. Construction: Weatherproof housing for replaceable, dry-type filter element, with silencer tubes or other method of sound reduction.
2. Capacity: Match total capacity of connected air compressors, with filter having collection efficiency of 99 percent retention of particles larger than 10 micrometers.

2.13 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 22 05 12, GENERAL MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT.

1. Enclosure: Totally enclosed, fan cooled .
2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load does not require motor to operate in service factor range above 1.0.

PART 3 - EXECUTION

3.1 INSTALLATION

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

B. 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.

C. All pipes shall be installed at right angles or parallel to building walls. Diagonal runs are prohibited unless indicated.

D. 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.

E. Piping installed adjacent to equipment shall be located to allow for the required service clearances.

F. Air and drain piping shall be installed with a 1 percent slope downward in direction of flow.

G. Nipples, flanges, unions, transitions, and special fittings, and valves shall be installed with pressure ratings same as or higher than system pressure rating.

H. Cast copper alloy companion flange with gasket and brazed soldered joints shall be used to connect equipment and specialties with flanged connections.

I. Flanged joints may be used instead of specified joint for any piping or tubing system.

J. 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.

K. 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.

L. Thermometers and pressure gauges shall be installed on discharge piping from each air compressor and on each receiver.

M. Valves shall be installed to permit servicing to all equipment.

N. Pipes shall be installed free of all sags and bends.

O. Seismic restraint shall be installed for all piping and equipment as required for location.

P. Piping shall be cut square and accurately with a tube cutter (sawing is prohibited) to measurements determined at place of installation and worked into place without springing or forcing the pipe. Tube shall 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.

Q. 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.

R. Hanger spacing shall be based upon NFPA 99.

S. 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.

T. Rigidly support valves and other equipment to prevent strain on tube or joints.

U. Compressor assembly shall have an equipment identification nameplate and data in accordance with 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

V. Suitably brace piping against sway and vibration. Bracing shall consist of brackets, anchor chairs, rods, and structural steel for vibration isolation.

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 34 kPa (5 psig).

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 34 kPa (5 psig) 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. Perform tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part. 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 345 kPa (50 psig) higher than the MAWP, minimum of 1034 kPa (150 psig). 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 percent of the MAWP until 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 de-pressurized 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 ensure 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 COR.

I. Duration of a test will be determined by the COR and will be for a minimum of 15 minutes with a maximum of 24 hours. Test may be terminated by direction of the COR 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 gauge 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 cost or time to the Government. 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.

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

3.4 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 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 4 hours to instruct each VA personnel responsible in operation and maintenance of the system.

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

- - - E N D - - -

SECTION 22 31 11
WATER SOFTENERS

PART 1 – GENERAL

1.1 DESCRIPTION

A. Provide sodium cycle, cation exchange, pressure type, water softening equipment complete with piping services, electrical services, controls, accessories and auxiliary 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 91 00, GENERAL COMMISSIONING REQUIREMENTS.

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

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

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

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):

B16.1-2010..............Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, 250

B16.3-2011..............Malleable Iron Threaded Fittings: Classes 150 and 300

B40.100-2013............Pressure Gauges and Gauge Attachments

ASME Boiler and Pressure Vessel Code -

BPVC Section VIII-1-2015 Rules for Construction of Pressure Vessels, Division 1

BPVC Section X-2015.....Fiber-Reinforced Plastic Pressure Vessels

C. American Society of Sanitary Engineering (ASSE):

1013-2011...............Performance Requirements for Reduced Pressure Principle Backflow Preventers and Reduced

Pressure Principle Fire Protection Backflow Preventers

D. ASTM International (ASTM):

A6/A6M-2014.............Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling

A53/A53M-2012..........Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc Coated, Welded and Seamless

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

E. American Water Works Association (AWWA):

B300-2010...............Hypochlorites

B301-2010...............Liquid Chlorine

C511-2007...............Reduced-Pressure Principle Backflow Prevention Assembly

C651-2014...............Disinfecting Water Mains

F. Federal Specifications (Fed. Spec.):

A-A-694D-2002..........Sodium Chloride, Technical

G. Department of Health and Human Services, Food and Drug Administration (FDA):

CFR 21, Chapter 1, Part 173.25, Ion-Exchange Resins

CFR 21, Chapter 1, Part 175.300, Resinous and Polymeric Coatings (Bio-based materials shall be utilized when possible.)

H. International Code Council (ICC):

IPC-2012................International Plumbing Code

I. National Electrical Manufacturers Association (NEMA):

ICS 6-1993 (R2001, R2006) Industrial Control and Systems: Enclosures

J. NSF International (NSF):

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

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

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

979-2005 (R2014)........Standard for Water Treatment Appliances

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 31 11, WATER SOFTENERS”, 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. Softener tank construction, coatings and linings. Bio-based materials shall be utilized when possible.
2. Tank distribution system design.
3. Main operating valve.
4. Control system and flow meter.
5. Wiring diagram for controls.
6. Exchange resin.
7. Brine system.
8. Accessories including pressure gages and test kit.
9. Performance data including normal and maximum flow and pressure drop. Certification that required performance shall be achieved.
10. Piping.

D. Complete detailed layout, setting, arrangement, and installation drawings including electrical/pneumatic controls. Drawings shall also show all parts of the apparatus including relative positions, dimensions, and sizes and general arrangement of connecting piping.

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

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

1.5 QUALITY ASSURANCE

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

1.6 PROJECT CONDITIONS

A. Water sample shall be tested by USEPA certified testing laboratory. Sample shall be taken by water softener equipment contractor and submitted for testing.

B. Influent Water Analysis:

Perform water analysis prior to beginning work.

C. Design Parameters:

Daily Hours of Water Demand: 14,000-17,000 gallons

Operating Temperature Range: 4 to 49 degrees C (40 to 120 degrees F)

Operating Pressure Range (System): 70-80 psig

Electrical Requirements: Dedicated 460 v, 60 Hz, 3 phase receptacle.

1.7 AS-BUILT DOCUMENTATION

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

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

C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. As-built drawings are to be provided, and a copy of them in Auto-CADD provided on compact disk or DVD. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the ‘third party testing company’ requirement.

D. Certification documentation shall be provided to COR 10 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and certification that all results of tests were within limits specified.

PART 2 - PRODUCTS

2.1 MATERIALS

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

2.2 SOFTENING SYSTEM

A. Vertical, down flow, pressure type with automatic controls to operate on sodium cycle. Automatic-alternating duplex units. Designed for 690 kPa (100 psig) working pressure. All materials exposed to water shall be considered as generally safe by the Food and Drug Administration (FDA). System shall comply with UL 979.

B. Performance Requirements:

1. Continuous flow of zero hardness soft water (use hardness test strips) with influent water conditions and flows listed in Part 1, with only one of the duplex units in service.
2. Exchanger material shall not wash out of apparatus during any softening run regardless of rate of flow.
3. Turbidity and color of treated water shall not increase above that of raw water.
4. Dirty or turbid water shall not occur during any softening run, regardless of changes in demand rate.
5. Strainer system, gravel bed, and exchange material shall not become fouled, either by turbidity in the raw water, or by dirt, rust or scale from pipe to the extent to render backwash ineffective.
6. Regeneration shall be accomplished within a period of 75 minutes and occur not more than once per day. Regeneration period shall be that part of cycle of operation from the time unit has delivered its

softening capacity until it is ready to be delivering soft water again, including all backwashing, brining and brine washout, complete. Amount of salt necessary to completely recondition unit after a capacity run shall not exceed 240 kg per cubic meter (15 pounds per cubic foot) of existing material.

C. Softener Tanks–Steel:

1. Butt-welded steel conforming to ASTM A6/A6M. Test hydrostatically at 1.5 times the design pressure and provide certification. Sidewall height shall be adequate to allow 50 percent of the mineral bed depth for expansion. Tanks shall have openings for mineral filling and removal. Provide steel supports welded to tank before testing and labeling to hold tanks in operating position above floor and designed to resist seismic loading as required by IBC. Provide seismic calculations. Exterior shall be degreased, cleaned, and coated with manufacturer’s standard prime and finish coatings. Interior shall have near-white sandblast and lined with phenolic epoxy, 0.20 to 0.25 mm (8 to 10 mils) thick. Interior coating shall be chemically inert, non-toxic, odorless and meet the requirements of CFR 21, Chapter 1, Part 175.300. Bio-based materials shall be utilized when possible.

D. Distribution System: Soft water collector and backwash water distributor shall be non-clogging, single point and hub radial laterals, designed to not cause channeling in the bed, PVC, Schedule 80. The distributor system shall be fully covered by one layer of quartz under-bedding with no debris or fines mesh size from 16 to 40 and above.

E. Exchange Material: Solid virgin high capacity styrene base resinous material. Material shall be stable over the entire pH range with resistance to bead fracture from attrition or osmotic shock. Particle size 20 to 50 mesh and contain no agglomerates, shells, plates or other shapes that might interfere with the functioning of the softener. Exchange capacity as $CaCO_3$ shall be considered to be 840 grains per cubic meter (23.8 grains per cubic foot) at 240 kg per cubic meter (15 pounds per cubic foot) salt dosage. Resin shall not require dosing or addition of any chemical, mixture, or solution to the water requiring treatment, or the water used for backwashing, other than NaCl for regeneration. Resin shall be FDA compliant under CFR 21, Chapter 1, Part 173.25.

F. Brine Measuring Tank with Cover: Rotationally molded high density polyethylene. Tank sized to provide a minimum of four regenerations per load of salt at a full salting. Tank shall include elevated salt plate and a chamber to house the brine valve assembly.

G. Brine System Controls: Automatic valve shall open to admit brine to softener and close to prevent air admission to the softener. During refill, the valve shall regulate flow of soft water to the brine tank. Provide float-operated safety valve to prevent brine tank overfill.

H. System Controls:

1. The controller shall be completely automatic and shall sequence all steps of regeneration and return the softener to a service or stand-by mode and alternate the duplex units. Selectable time or flow meter initiated regeneration. The initiating time or volume set points shall automatically reset upon initiation of the regeneration sequence. Controller shall permit manual initiation of regeneration.
2. Computer-based field-programmable controller with selectable flow meter based and time clock based operating cycles. The controller shall utilize alphanumeric, self-prompting programming for simple startup. EEPROM memory shall store program data eliminating need for battery back up on configuration input after power loss. Self-diagnostic and capable of emitting an audible error signal and displaying error-specific messages. Lockout function to prevent unauthorized access to the program data. Sealed keypad with capability of all programming functions. Fluorescent alphanumeric display on face of controller. Enclose controls in NEMA ICS 6; Type 4X enclosure mounted approximately 1.5 meters (5 feet) above the floor.
3. Operating conditions shall be continuously monitored, and display shall show time of day, volume remaining before next regeneration, number of regenerations in last 14 days, number of days since last regeneration, instantaneous flow rate, resettable totalized flow since the last regeneration, time of next regeneration, and identify the cycle that is in progress.
4. Flow shall be regulated to prevent resin loss, operate between 200 and 690 kPa (29 and 100 psig) supply pressure, and prevent noise and

hydraulic shock. Control shall permit only one unit to regenerate at a time.

5. Flow meter shall have turndown range of 60/1, minimum accuracy of +/-1 percent of maximum range, repeatability of +/-0.5 percent of full range. Install with manufacturer's recommended straight pipe before and after the meter.
6. Main operating valve shall be a fully automatic multiport diaphragm type or valve nest constructed of cast iron or corrosion resistant alloy material with hard-coat anodization and final coat of flouroplate polymer. Coating shall resist 1000 hour/5 percent salt spray test without sign of corrosion. Bio-based materials shall be utilized when possible. Valves shall be slow opening and closing, free of water hammer; diaphragm assembly shall be fully guided. All valve parts accessible for service. The main operating valve shall include a valve mounted automatic self-adjusting brine injector to draw brine and control rinse at a constant rate regardless of water pressure in the range of 200 to 690 kPa (29 to 100 psig). Valve shall have soft water sampling cock and indicator to show system status.

I. Sampling Cocks: Provide for hard and soft water.

J. Sodium Chloride: Fed. Spec. A-A-694D. Provide sufficient quantity for ten regenerations.

2.3 EXTERNAL SOFTENER PIPING

A. Pipe: ASTM A53/A53M, stainless steel or PVC, ASTM D1785, Schedule 80 .

B. Fittings: PVC, Schedule 80 or stainless steel.

C. Flanges: ASME B16.1, Class 125.

D. Threaded Joints: Shall be made with ends reamed out. Apply bituminous base lubricant or fluorocarbon resin tape to male threads only. Bio-based materials shall be utilized when possible.

2.4 BRINE PIPING

A. Polyvinyl chloride (PVC), ASTM D1785, Schedule 80 with solvent welded joints.

2.5 VALVES

A. Ball: Carbon steel body, stainless steel trim, reinforced Teflon seat and seal, full port, threaded ends.

2.6 PRESSURE GAGES

A. ASME B40.100, Grade A, 1 percent accuracy, 115 mm (4-1/2 inches) diameter, all metal case, bottom connected. White dials, black hands, graduated from 0 to 690 kPa (0 to 100 psig) and identity labeled. Provide gages with gage cocks at softener hard water inlet and soft water outlet to show pressure drop thru softener.

2.7 REDUCED PRESSURE BACKFLOW PREVENTER

A. Provide on suction side of water softener serving boilers. Parts shall be made of corrosion-resistant materials and shall be of heavy duty construction, 861 kPa (125 psig) class minimum. Backflow preventer shall meet the requirements of ICC IPC, ASSE 1013, and AWWA C511.

2.8 WATER TESTING EQUIPMENT

A. Furnish water testing hardness test strips which measure 0-25 grains of hardness with minimum bottle of 50 strips with color code chart for reading test strips.

PART 3 – EXECUTION

3.1 REQUIRED TECHNICAL SERVICES

A. Provide services of a qualified manufacturer's representative to check complete installation for conformance to manufacturer's recommendation, put system into service, make all adjustments required for full conformance to design and specified requirements, and perform all demonstrations and tests.

3.2 FLUSHING AND DISINFECTING

A. Flush and disinfect new water lines and softener interiors in accordance with AWWA C651.

B. Material:

1. Liquid chlorine: AWWA B301.
2. Hypochlorite: AWWA B300.

3.3 STARTUP AND TESTING

A. Operating: Tests shall be conducted in presence of COR. It is prohibited, for testing purposes, to add to or subtract from exchange material used in apparatus, neither will any regenerating agent, other than the solution specified, be permitted.

B. Procedure:

1. Regenerate system to demonstrate operation of multiport valve.
2. Operate each softener at constant maximum required capacity for ten minutes after soft water is produced. When necessary, waste softened

water to sewer to maintain above flow rate. Contractor shall submit samples to a USEPA certified testing laboratory. A certified test report shall be prepared indicating hardness levels are within the specified range. Hardness shall be less than 50 mg/L or as specified.

3. Demonstrate all features of the control system including diagnostics and flow and cycle indications.

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

3.4 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 MAINTENANCE SERVICE

A. Provide full maintenance contract by service technician of water softener manufacturers, including preventative maintenance as required for proper operation of water softener equipment. Servicing company shall be within 2 hours drive and be capable of responding within 6 to 8 hours.

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SECTION 22 34 00
FUEL-FIRED DOMESTIC WATER HEATERS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section describes the requirements for installing a complete gas fired domestic water heating system ready for operation including water heaters, thermometers, and all necessary accessories, connections, and equipment.

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

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.
B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.
C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.
D. Section 03 30 00, CAST-IN-PLACE CONCRETE: Concrete and Grout.
E. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS: Seismic Restraint for Equipment.
F. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.
G. Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

1.3 APPLICABLE PUBLICATIONS

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

B. American National Standard Institute (ANSI):

Z21.10.1-2019...........Gas Water Heaters, Volume I, Storage Water Heaters with Input Ratings of 75,000 Btu per Hour or Less

Z21.10.3-2019...........Gas-Fired Water Heaters, Volume III, Storage Water Heaters with Input Ratings Above 75,000 Btu per Hour, Circulating and Instantaneous

Z21.15-2009(R2014)......Manually Operated Gas Valves for Appliances, Appliance Connector Valves and Hose End Valves

Z21.18-2019.............Gas Appliance Pressure Regulators

Z21.20-2005(R2016)......Automatic Gas Ignition Systems and Components

Z21.21-2019.............Automatic Valves for Gas Appliances

Z21.22-2015.............Relief Valves for Hot Water Supply Systems

Z21.66-2015.............Automatic Damper Devices for Use with Gas-Fired Appliances

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

90.1-2019...............Energy Standard for Buildings Except Low-Rise Residential Buildings

D. American Society of Mechanical Engineers (ASME):

ASME Boiler and Pressure Vessel Code –

BPVC Section IV-2019....Rules for Construction of Heating Boilers

BPVC Section VIII-1-2019 Rules for Construction of Pressure Vessels, Division 1

Form U-1................Manufacturer’s Data Report for Pressure Vessels

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

B1.20.7-1991............Hose Coupling Screw Threads (Inch)

B16.5-2017..............Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard

B16.24-2016.............Cast Copper Alloy Pipe Flanges, Flanged Fittings, and Valves: Classes 150, 300, 600, 900, 1500, and 2500

CSD-1-2018..............Controls and Safety Devices for Automatically Fired Boilers

E. National Electrical Manufacturers Association (NEMA):

ICS 6-1993(R2016).......Industrial Control and Systems: Enclosures

F. National Fire Protection Association (NFPA):

54-2018.................National Fuel Gas Code

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

G. NSF International (NSF):

5-2019..................Water Heaters, Hot Water Supply Boilers, and Heat Recovery Equipment

61-2018.................Drinking Water System Components – Health Effects

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

H. Underwriters Laboratories, Inc. (UL):

429-2013(R2020).........Standard for Electrically Operated Valves

795-2016................Standard for Commercial-Industrial Gas Heating 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 34 00, FUEL-FIRED 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.

1. Water Heaters.
2. Pressure and Temperature Relief Valves.
3. Thermometers.
4. Pressure Gauges.
5. Vacuum Breakers.
6. Expansion Tanks.
7. Heat Traps.
8. Gas Shut-off Valves.
9. Motorized Gas Valves.
10. Gas Pressure Regulators.
11. Manifold Kits.

D. For each gas fired 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
5. A Form U-1 or other documentation stating compliance with the ASME Boiler and Pressure Vessel Code.

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

F. Seismic qualification certificates shall be submitted that details equipment anchorage components that identifies equipment center of gravity with mounting and anchorage provisions, and whether the seismic qualification certificate is based on an actual test or calculations.

G. Submit documentation indicating compliance with applicable requirements of ASHRAE 90.1 or Energy Star for Service Water Heating.

H. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replaceable parts, and troubleshooting guide:

1. Include complete list indicating all components of the systems.
2. Include complete diagrams of the internal wiring for each item of equipment.
3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

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

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

1.5 QUALITY ASSURANCE

A. Gas water heaters up to 530 liters (140 gallons) are covered under the FEMP and the ENERGY STAR program. Federal laws and executive orders mandate the purchase of gas water heaters that meet or exceed the ENERGY STAR listed minimum efficiency. 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. ASME code construction shall be a vessel fabricated in compliance with the ASME BPVC Section VIII-1.

D. Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61 and NSF 372.

E. The gas fired domestic water heater shall conform to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS on seismic restraint requirements, withstanding seismic movement without separation of any parts from the equipment when subjected to a seismic event.

F. The domestic water heater shall be certified and labeled by an independent testing agency.

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

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

1.6 AS-BUILT DOCUMENTATION

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

PART 2 - PRODUCTS

2.1 POWER VENT, GAS FIRED, STORAGE DOMESTIC WATER HEATERS

A. The gas fired domestic water heater shall comply with ANSI Z21.10.1 ANSI Z21.10.3. Provide with access for cleaning and disinfection.

B. The water heater design shall provide a minimum combustion efficiency of 95 percent at operating conditions. Water heater capacities are scheduled on the drawings.

C. The tank construction shall be ASME BPVC Section VIII-1, unlined lean duplex alloy stainless-steel, glass lined, with 1034 kPa (150 psig) working pressure rating complying with NSF 61 and NSF 372 for barrier materials for potable water tank linings.

D. The tapping (openings) shall be factory-fabricated of materials compatible with the tank and in accordance with appropriate ASME standards for piping connection, pressure and temperature relief valve, pressure gauge, thermometer, drain valve, anode rods and controls. The tappings shall be:

1. 50 mm or DN50 (NPS 2 inch) and smaller: Threaded ends according to ASME B1.20.1.

2. 65 mm or DN65 (NPS 2-1/2 inch) and larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24.

E. The gas-fired burner shall include the following:

1. Thermostatic adjustment.
2. Designed for use with power vent heaters.
3. High temperature limit and low water cutoff devices for safety controls.
4. Automatic ignition in accordance with ANSI Z21.20.
5. Automatic damper in accordance with ANSI Z21.66. The automatic dampers shall be thermally activated, automatic vent damper device with size matching draft hood for 300,000 BTUH and below.

F. Temperature setting shall be set for a minimum water temperature of 60 degrees C (140 degrees F). The temperature setting shall be adjustable. Heaters shall be capable of raising the discharge temperature to 77 to 82 degrees C (170 to 180 degrees F) for thermal eradication.

G. The insulation shall surround the entire storage tank except connection and controls and shall comply with ASHRAE 90.1.

H. The jacket shall be steel with enameled finish.

I. The drain valve shall be corrosion resistant metal. A drain valve shall be installed at the bottom of each tank-type water heater and hot water storage tank. The drain valve inlet shall not be less than 20 mm or DN20 (NPS 3/4 inch) with ASME B1.20.7 garden hose threads.

J. Anode rod shall be replaceable magnesium.

K. The power vent system shall be interlocked with the burner.

L. The combination pressure and temperature relief Valve shall be ANSI Z21.22 rated and constructed of all brass or bronze with a self-closing reseating valve.

M. Special requirements: NSF 5 construction.

2.2 CONDENSING, GAS FIRED, STORAGE DOMESTIC WATER HEATERS

A. The gas fired domestic water heater shall comply with ANSI Z21.10.1 ANSI Z21.10.3. Provide with access for cleaning and disinfection.

B. The water heater design shall provide a minimum combustion efficiency of 95 percent at operating conditions. Water heater capacities are scheduled on the drawings.

C. The tank construction shall be ASME BPVC Section VIII-1, glass lined, with 861 kPa (125 psig) working pressure complying with NSF 61 and NSF 372 for barrier materials for potable-water tank linings.

D. The tapping (openings) shall be factory-fabricated of materials compatible with the tank and in accordance with appropriate ASME standards for piping connection, pressure and temperature relief valve, pressure gauge, thermometer, drain valve, anode rods and controls. The tappings shall be:

1. 50 mm or DN50 (NPS 2 inch) and smaller: Threaded ends according to ASME B1.20.1.
2. 65 mm or DN65 (NPS 2-1/2 inch) and larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24.

E. The natural gas-fired burner shall include the following:

1. Metal-fiber mesh covering a stainless-steel body with spark ignition and flame rectification.
2. All burner material exposed to the combustion zone shall be of stainless-steel construction.
3. High temperature limit and low water cutoff devices for safety controls.
4. Automatic ignition in accordance with ANSI Z21.20.
5. The modulating motor shall be linked to both the gas valve body and air valve body with a single linkage. The linkage shall not require any field adjustment.

F. The control shall provide an integral sensor set point adjustment. The set point shall be adjustable in 1 degrees C (1 degrees F) increments.

G. Temperature Setting shall be set for a minimum water temperature of 60 degrees C (140 degrees F). The temperature setting shall be adjustable. Heaters shall be capable of raising the discharge temperature to 77 to 82 degrees C (170 to 180 degrees F) for thermal eradication.

H. The drain valve shall be corrosion resistant metal. A drain valve shall be installed at the bottom of each tank-type water heater and hot water storage tank. The drain valve inlet shall not be less than 20 mm or DN20 (NPS 3/4 inch) with ASME B1.20.7 garden hose threads.

I. The power vent system shall be interlocked with the burner.

J. The combination pressure and temperature relief valve shall be ANSI Z21.22 rated and constructed of all brass or bronze with a self-closing reseating valve.

K. Special requirements: NSF 5 construction.

2.3 DOMESTIC HOT WATER EXPANSION TANKS

A. A steel pressure rated tank constructed with welded joints and factory installed butyl rubber diaphragm shall be installed as scheduled. The air precharge shall be set to minimum system operating pressure at tank.

B. The tappings shall be factory-fabricated steel, welded to the tank and include ASME B1.20.1 pipe thread.

C. The interior finish shall comply with NSF 61 and NSF 372 barrier materials for potable water tank linings and the liner shall extend into and through the tank fittings and outlets.

D. The air charging valve shall be factory installed.

2.4 HEAT TRAPS

A. Heat traps shall be installed in accordance with ASHRAE 90.1 if not provided integral with the heater.

2.5 COMBINATION TEMPERATURE AND PRESSURE RELIEF VALVES

A. The combination pressure and temperature relief valve shall be ANSI Z21.22 and ASME rated and constructed of all brass or bronze with a self-closing reseating valve. The relief valves shall include a relieving capacity greater than the heat input and include a pressure setting less than the water heater’s working pressure rating. Sensing element shall extend into storage tank.

2.6 GAS SHUTOFF VALVES

A. The gas shutoff valve shall be manually operated with proof of closure conforming to ANSI Z21.15.

B. In high seismic areas, an earthquake shear valve shall be installed.

2.7 MOTORIZED GAS VALVES

A. Automatic Gas Valves: Comply with ANSI Z21.21 and shall have the following characteristics:

1. Body: Brass or aluminum.
2. Seats and Disc: Nitrile rubber.
3. Springs and Valve Trim: Stainless-steel.
4. Normally closed.

5. Visual position indicator.
6. Electrical operator for actuation by appliance automatic shutoff device.

B. Electrically Operated Valves: Comply with UL 429 and shall have the following characteristics:
1. Pilot operated.
2. Body: Brass or aluminum.
3. Seats and Disc: Nitrile rubber.
4. Springs and Valve Trim: Stainless-steel.
5. 120-V ac, 60 Hz, Class B, continuous-duty molded coil, and replaceable.
6. NEMA ICS 6, Type 4, coil enclosure.
7. Normally closed.
8. Visual position indicator.

2.8 GAS PRESSURE REGULATORS

A. The gas pressure regulator shall be appliance type, pressure rating matching inlet gas supply temperature, and conforming to ANSI Z21.18.

2.9 AUTOMATIC GAS VALVES

A. Each water heater shall incorporate dual over-temperature protection with manual reset, in accordance with ASME BPVC Section IV and ASME CSD-1. The automatic gas valves shall be appliance type, electrically operated, on-off automatic control, and conforming to ANSI Z21.21.

2.10 THERMOMETERS

A. Thermometers shall be rigid stem or remote sensing, scale or dial type with an aluminum, black metal, stainless-steel, or chromium plated brass case. The thermometer shall be back connected, red liquid (alcohol or organic-based) fill, vapor, bi-metal or gas actuated, with 228 mm (9 inches) high scale dial or circular dial 50 to 127 mm (2 to 5 inches) in diameter graduated from 4 to 100 degrees C (40 to 212 degrees F), with two-degree graduations guaranteed accurate within one scale division. The socket shall be separable, double-seat, micrometer-fittings, with extension neck not less than 63 mm (2-1/2 inches) to clear tank or pipe covering. The thermometer shall be suitable for 19 mm (3/4 inch) pipe threads. Thermometers may be console-mounted with sensor installed in separate thermometer well.

2.11 SUPPORTS

A. Water heater stands shall be factory-fabricated steel for floor mounting capable of supporting water heater and water a minimum of 457 mm (18 inches) above the floor.

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

2.12 MANIFOLD KITS

A. For multiple water heater installation, provide factory-fabricated copper manifold kits to include ball-type shutoff valves to isolate each water heater and balancing valves to provide balanced flow through each water heater.

PART 3 - EXECUTION

3.1 INSTALLATION

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

B. The water heaters shall be installed on concrete bases unless elevated above the floor. Refer to Section 03 30 00, CAST-IN-PLACE CONCRETE and Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

C. The water heaters shall be installed level and plumb and securely anchored.

D. The water heaters shall be installed and connected in accordance with manufacturer’s written instructions with manufacturer’s recommended clearances.

E. All pressure and temperature relief valves discharge shall be piped to a nearby floor drains with air gap or break.

F. 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.

G. Vent piping from gas-train pressure regulators and valves shall be piped to the outside of building and shall conform to NFPA 54.

H. The thermostatic control shall be set for a minimum setting of 60 degrees C (140 degrees F) for storage heaters.

I. Shutoff valves shall be installed on the domestic water supply piping to the water heater and on the domestic hot water outlet piping.

J. All manufacturer’s required clearances shall be maintained.

K. The gas fueled domestic water heaters shall be installed with seismic restraint devices.

L. A combination temperature and pressure relief valve shall be installed at the top portion of the storage tank in accordance with manufacturer’s recommendations. The sensing element shall extend into the tank. The relief valve outlet drain piping shall discharge by air gap into a floor drain.

M. Piping type heat traps shall be installed on the inlet and outlet piping of the domestic water heater storage tanks, unless provided integrally with the tanks.

N. Water heater drain piping shall be installed as indirect waste to spill by air gap into open drains or over floor drains. Hose end drain valves shall be installed at low points in water piping for gas fueled domestic hot water heaters without integral drains.

O. The type B galvanized or stainless-steel combustion vent shall be installed and sized according to the water heaters recommendations and extended through the roof or wall as allows by the local fuel gas code or NFPA 54. Install vents for condensing heaters in accordance with manufacturer’s recommendations.

P. Provide acid neutralization kits for condensing water heaters.

Q. Dielectric unions shall be provided if there are dissimilar metals between the water heater connections and the attached piping.

R. Provide vacuum breakers per ANSI Z21.22 on the inlet pipe if the water heater is bottom fed.

3.2 LEAKAGE TEST

A. Before piping connections are made, the water heaters shall be tested at a hydrostatic pressure of 1380 kPa (200 psig) and 1654 kPa (240 psig) for a unit with a MAWP of 1104 kPa (160 psig). If any leakage is found on the water heater, the water heater shall be replaced with a new unit at no additional cost to the VA.

3.3 PERFORMANCE TEST

A. Ensure that all the remote water outlets are always tested to a minimum of 43 degrees C (110 degrees F) and a maximum of 49 degrees C (120 degrees F) water flow.

3.4 STARTUP AND TESTING

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

B. 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 cost or time to the Government.

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

3.5 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 4 hours to instruct each VA personnel responsible in operation and maintenance of the system.

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

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SECTION 22 40 00
PLUMBING FIXTURES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Plumbing fixtures, associated trim and fittings necessary to make a complete installation from wall or floor connections to rough piping, and certain accessories.

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

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

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

C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

D. Section 07 92 00, JOINT SEALANTS: Sealing between fixtures and other finish surfaces.

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

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

G. 22 13 00, FACILITY SANITARY AND VENT PIPING.

1.3 APPLICABLE PUBLICATIONS

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

B. The American Society of Mechanical Engineers (ASME):

A112.6.1M-1997 (R2012)..Supports for Off-the-Floor Plumbing Fixtures for Public Use

A112.19.1-2013..........Enameled Cast Iron and Enameled Steel Plumbing Fixtures

A112.19.2-2013..........Ceramic Plumbing Fixtures

A112.19.3-2008..........Stainless Steel Plumbing Fixtures

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

A276-2013a..............Standard Specification for Stainless Steel Bars and Shapes

B584-2008...............Standard Specification for Copper Alloy Sand Castings for General Applications

D. CSA Group:

B45.4-2008 (R2013)......Stainless Steel Plumbing Fixtures

E. National Association of Architectural Metal Manufacturers (NAAMM):

AMP 500-2006............Metal Finishes Manual

F. American Society of Sanitary Engineering (ASSE):

1016-2011...............Automatic Compensating Valves for Individual Showers and Tub/Shower Combinations

G. NSF International (NSF):

14-2013.................Plastics Piping System Components and Related Materials

61-2013.................Drinking Water System Components – Health Effects

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

H. American with Disabilities Act (A.D.A)

I. International Code Council (ICC):

IPC-2015................International Plumbing Code

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 40 00, PLUMBING FIXTURES”, with applicable paragraph identification.

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

D. Operating Instructions: Comply with requirements in Section 01 00 00, GENERAL REQUIREMENTS.

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

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

1.5 QUALITY ASSURANCE

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

1.6 AS-BUILT DOCUMENTATION

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

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

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

D. Certification documentation shall be provided to COR 10 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and certification that all results of tests were within limits specified.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Material or equipment containing a weighted average of greater than 0.25 percent lead is 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.

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

2.2 STAINLESS STEEL

A. Corrosion-resistant Steel (CRS):

1. Plate, Sheet and Strip: CRS flat products shall conform to chemical composition requirements of any 300 series steel specified in ASTM A276.
2. Finish: Exposed surfaces shall have standard polish (ground and polished) equal to NAAMM finish Number 4.

B. Die-cast zinc alloy products are prohibited.

2.3 STOPS

A. Provide lock-shield loose key or screw driver pattern angle stops, straight stops or stops integral with faucet, with each compression type faucet whether specifically called for or not, including sinks in solid-surface, wood and metal casework, laboratory furniture and pharmacy furniture. Locate stops centrally above or below fixture in accessible location.

B. Furnish keys for lock shield stops to the COR.

C. Supply from stops not integral with faucet shall be chrome plated copper flexible tubing or flexible stainless steel with inner core of non-toxic polymer.

D. Supply pipe from wall to valve stop shall be rigid threaded IPS copper alloy pipe, i.e. red brass pipe nipple, chrome plated where exposed.

E. Mental Health Area: Provide stainless steel drain guard for all lavatories not installed in casework.

2.4 ESCUTCHEONS

A. Heavy type, chrome plated, with set screws. Provide for piping serving plumbing fixtures and at each wall, ceiling and floor penetrations in exposed finished locations and within cabinets and millwork.

2.5 LAMINAR FLOW CONTROL DEVICE

A. Smooth, bright stainless steel or satin finish, chrome plated metal laminar flow device shall provide non-aeration, clear, coherent laminar flow that will not splash in basin. Device shall also have a flow control restrictor and have vandal resistant housing. **Aerators are prohibited.**

B. Flow Control Restrictor:

1. Capable of restricting flow from 32 ml/s to 95 ml/s (0.5 gpm to 1.5 gpm) for lavatories; 125 ml/s to 140 ml/s (2.0 gpm to 2.2 gpm) for sinks P-505 through P-520, P-524 and P-528; and 174 ml/s to 190 ml/s (2.75 gpm to 3.0 gpm) for dietary food preparation and rinse sinks or as specified.
2. Compensates for pressure fluctuation maintaining flow rate specified above within 10 percent between 170 kPa and 550 kPa (25 psig and 80 psig).
3. Operates by expansion and contraction, eliminates mineral/sediment build-up with self-cleaning action, and is capable of easy manual cleaning.

2.6 CARRIERS

A. ASME A112.6.1M, with adjustable gasket faceplate chair carriers for wall hung closets with auxiliary anchor foot assembly, hanger rod support feet, and rear anchor tie down.

B. ASME A112.6.1M, lavatory, concealed arm support. All lavatory chair carriers shall be capable of supporting the lavatory with a 250-pound vertical load applied at the front of the fixture.

C. Where water closets, lavatories or sinks are installed back-to-back and carriers are specified, provide one carrier to serve both fixtures in lieu of individual carriers. The drainage fitting of the back to back carrier shall be so constructed that it prevents the discharge from one fixture from flowing into the opposite fixture.

2.7 WATER CLOSETS

A (P-103) Water Closet (Wall Hung, ASME A112.19.2) office and industrial, elongated bowl, siphon jet 4.8 L (1.28 gallons) per flush, wall outlet. Top of seat shall be between 400 mm and 432 mm (16 inches and 17 inches) above finished floor. Handicapped water closet shall have seat set 450 mm (18 inches) above finished floor.

1. Seat: Institutional/Industrial, extra heavy duty, chemical resistant, solid plastic, open front less cover for elongated bowls, integrally molded bumpers, concealed check hinge with stainless steel post. Seat shall be posture contoured body design. Color shall be white.
2. Fittings and Accessories: Gaskets-neoprene; bolts with chromium plated caps nuts and washers and carrier.
3. Flush valve: Large chloramines resistant diaphragm, semi-red brass valve body, exposed chrome plated, non-hold open ADA approved side oscillating handle, water saver design per flush with maximum 10 percent variance 25 mm (1 inch) screwdriver back check angle stop with vandal resistant cap, adjustable tailpiece, a high back pressure vacuum breaker, spud coupling for 40 mm (1-1/2 inches) top spud, wall and spud flanges, solid-ring pipe support, and sweat solder adapter with cover tube and set screw wall flange. Valve body, cover, tailpiece and control stop shall be in conformance with ASTM alloy classification for semi-red brass. Seat bumpers shall be integral part of flush valve. Set centerline of inlet 292 mm (11-1/2 inches) above seat.

2.8 LAVATORIES

A. Dimensions for lavatories are specified, Length by width (distance from wall) and depth.

B. Brass components in contact with water shall contain no more than 0.25 percent lead content by dry weight. Faucet flow rates shall be 3.9 L/m (1.5 gpm) for private lavatories and either 1.9 L/m (0.5 gpm) or 1.0 liter (0.25 gallons) per cycle for public lavatories.

C. (P-414) Lavatory (Wrist Control, ASME A112.19.2) straight back, approximately 508 mm by 457 mm (20 inches by 18 inches) and a 102 mm (4 inches) minimum apron, first quality vitreous china. Punching for faucet shall be on 203 mm (8 inches) centers. Set rim 864 mm (34 inches) above finished floor.

1. Faucet: Solid cast brass construction with washerless ceramic mixing cartridge type and centrally exposed rigid gooseneck spout with outlet 102 mm to 127 mm (4 inches to 5 inches) above rim. Provide laminar flow control device. One hundred two millimeter (4-inch) wrist blade type, handles on faucets shall be cast, formed or drop forged copper alloy. Faucet, wall and floor escutcheons shall be either copper alloy or CRS. Exposed metal parts, including exposed part under valve handle when in open position, shall be chrome plated with a smooth bright finish.
2. Drain: Cast or wrought brass with flat grid strainer, offset tailpiece, chrome plated.
3. Stops: Angle type. See paragraph “Stops”.
4. Trap: Cast copper alloy, 38 mm by 32 mm (1 1/2 inches by 1 1/4 inches) P-trap. Adjustable with connected elbow and 1.4 mm thick (17 gauge) tubing extension to wall. Exposed metal trap surface, and connection hardware shall be chrome plated with a smooth bright finish. Set trap parallel to the wall.
5. Provide cover for exposed piping, drain, stops and trap per A.D.A.

2.9 SINKS AND LAUNDRY TUBS

A. Dimensions for sinks and laundry tubs are specified, length by width (distance from wall) and depth.
B. (P-502) Service Sink (Corner, Floor Mounted) stain resistant terrazzo, 711 mm by 711 mm by 305 mm (28 inches by 28 inches by 12 inches) with 152 mm (6 inches) drop front. Terrazzo, composed of marble chips and white Portland cement, shall develop compressive strength of 20684 kPa (3000 psig) seven days after casting. Provide extruded aluminum cap on front side.
   1. Faucet: Solid brass construction, 9.5 L/m (2.5 gpm) combination faucet with replaceable Monel seat, removable replacement unit containing all parts subject to wear, integral check/stops, mounted on wall above sink. Spout shall have a pail hook, 19 mm (3/4 inch) hose coupling threads, vacuum breaker, and top or bottom brace to wall. Four-arm handles on faucets shall be cast, formed, or drop forged copper alloy. Escutcheons shall be either forged copper alloy

or CRS. Exposed metal parts, including exposed part under valve handle when in open position, shall have a smooth bright finish. Provide 914 mm (36 inches) hose with wall hook. Centerline of rough in is 1219 mm (48 inches) above finished floor.

2. Drain: Seventy six millimeter (3 inches) cast brass drain with nickel bronze strainer.
3. Trap: P-trap, drain through floor.

C. (P-524) Sink, (CRS, Double Compartment, Counter Top, ASME A112.19.3, Kitchen Sinks) self-rimming, approximately 838 mm by 559 mm (33 inches by 22 inches) with two compartments inside dimensions approximately 343 mm by 406 mm by 191 mm (13 1/2 inches by 16 inches by 7 1/2 inches), minimum 20 gage CRS. Corners and edges shall be well rounded.
1. Faucet: Kitchen sink, solid brass construction, 8.3 L/m (2.2 gpm) swing spout, chrome plated copper alloy with spray and hose.
2. Drain: Drain plug with cup strainer, stainless steel.
3. Trap: Cast copper alloy, 38 mm (1 1/2 inches) P-trap with cleanout plug, continuous drain with wall connection and escutcheon.
4. Provide cover for exposed piping, drain, stops and trap per A.D.A.

D. (P-528) Sink (CRS, Single Compartment, Counter Top ASME A112.19.2, Kitchen Sinks) self-rimming, back faucet ledge, approximately 533 mm by 559 mm (21 inches by 22 inches) with single compartment inside dimensions approximately 406 mm by 483 mm by 191 mm (16 inches by 19 inches by 7 1/2 inches) deep. Shall be minimum of 1.3 mm thick (18 gauge) CRS. Corners and edges shall be well rounded:
1. Faucet: Solid brass construction, 8.3 L/m (2.2 gpm) deck mounted combination faucet with Monel or ceramic seats, removable replacement unit containing all parts subject to ware, swivel gooseneck spout with approximately 203 mm (8 inches) reach with spout outlet 152 mm (6 inches above deck and 102 mm (4 inches) wrist blades single lever with hose spray. Faucet shall be polished chrome plated.
2. Drain: Drain plug with cup strainer, stainless steel.
3. Trap: Cast copper alloy 38 mm (1 1/2 inches) P-trap with cleanout plug. Provide wall connection and escutcheon.

E. Standard rating conditions: 10 degrees C (50 degrees F) water with 27 degrees C (80 degrees F) inlet water temperature and 32 degrees C (90 degrees F) ambient air temperature.

F. (P-609) Electric Water Cooler: Mechanically cooled, self-contained, wheelchair, bubbler style fully exposed dual height stainless steel fountain, recessed in wall refrigeration system, stainless steel grille, stainless steel support arm, wall mounting box, energy efficient cooling system consisting of a hermetically sealed reciprocating type compressor, 115v, 60 Hz, single phase, fan cooled condenser, permanently lubricated fan motor. Set highest bubbler 1016 mm (40 inches) above finished floor. Provide with bottle filler option.

2.10 SHOWER BATH FIXTURE

A. (P-701) Shower Bath Fixture (Detachable, Wall Mounted, Concealed Supplies, Type T/P Combination Valve):

1. Shower Installation: Wall mounted detachable spray assembly, 600 mm (24 inch) wall bar, elevated vacuum breaker, supply elbow and flange and valve. All external trim, chrome plated metal.
2. Shower Head Assembly: Metallic shower head with flow control to limit discharge to 5.7 l/m (1.5 gpm) 9.5 l/m (2.5 gpm) , 1524 mm (60 inches) length of rubber lined CRS, chrome plated metal flexible, or white vinyl reinforced hose and supply wall elbow. Design showerhead to fit in palm of hand. Provide CRS or chrome plated metal wall bar with an adjustable swivel hanger for showerhead. Fasten wall bar securely to wall for hand support.
3. Valves: Type T/P combination thermostatic and pressure balancing, with chrome plated metal lever type operating handle adjustable for rough-in variations and chrome plated metal or CRS face plate. Valve body shall be any suitable copper alloy. Internal parts shall be copper, nickel alloy, CRS or thermoplastic material. Valve inlet and outlet shall be 13 mm (1/2 inch) IPS. Provide external screwdriver check stops, vacuum breaker and temperature limit stops. Set stops for a maximum temperature of 50 degrees C (122 degrees F). All exposed fasteners shall be vandal resistant. Valve shall provide a minimum of 5.7 l/m (1.5 gpm) at 310 kPa (45 psig) pressure drop.

2.11 EMERGENCY FIXTURES

A. (P-707) Emergency Shower and Eye and Face Wash (Free Standing):

1. Shower Head: Polished chrome plated, 203 mm (8 inches) in diameter, install head 2134 mm (84 inches) above floor. Equip with stay-open ball valve, chrome plated. Operate valve with 610 mm (24 inches) stainless steel pull-rod with triangle handle. Pull-down opens valve; push-up closes valve. Flow rate shall be 75.7 L/m (20 gpm).
2. Emergency Eye and Face Wash: CRS receptor. Equipment with a 13 mm (1/2 inch) stay open ball valve operated by push flag handle. Mount eye and face wash spray heads 1067 mm (42 inches) above finished floor. Flow rate shall be 11.4 L/m (3 gpm).
3. Provide with thermostatic mixing valve to provide tepid water from 30 to 35 degrees C (85 to 95 degrees F).
4. Shower head and emergency eye and face wash shall be mounted to stanchion with floor flange through floor waste connection and P-trap. Paint stanchion same color as room interior. Provide with signage to easily locate fixture.
5. Provide with emergency alarm horn and light. Tie alarm to BAS.

B. (P-708) Emergency Eye and Face Wash (Wall Mounted): CRS, wall mounted, foot pedal control. Mount eye and face wash spray heads 1067 mm (42 inches) above finished floor. Pedal shall be wall mounted, entirely clear of floor, and be hinged to permit turning up. Receptor shall be complete with drain plug with perforated strainer, P-trap and waste connection to wall with escutcheon. Provide with thermostatic mixing valve to provide tepid water from 30 to 35 degrees C (85 to 95 degrees F). Flow rate shall be 11.4 L/m (3 gpm).

2.12 HYDRANT, HOSE BIBB AND MISCELLANEOUS DEVICES

A. (P-801) Wall Hydrant: Cast bronze non-freeze hydrant with detachable T-handle. Brass operating rod within casing of bronze pipe of sufficient length to extend through wall and place valve inside building. Brass valve with coupling and union elbow having metal-to-metal seat. Valve rod and seat washer removable through face of hydrant; 19 mm (3/4 inch) hose thread on spout; 19 mm (3/4 inch) pipe thread on inlet. Finish may be rough; exposed surfaces shall be chrome plated. Set not less than 457 mm (18 inches) nor more than 914 mm (36 inches) above grade. On porches and platforms, set approximately 762 mm (30 inches) above finished floor. Provide integral vacuum breaker which automatically drains when shut off.

B. (P-804) Hose Bibb (Single Faucet, Wall Mounted to Concealed (bathroom) or Exposed (boiler floor) Supply Pipe): Cast or wrought copper alloy, single faucet with replaceable Monel seat, removable replacement unit containing all parts subject to wear, mounted on wall 914 mm (36 inches) above floor to concealed supply pipe. Provide faucet with 19 mm (3/4 inch) hose coupling thread on spout and vacuum breaker. Four-arm handle on faucet shall be cast, formed or drop forged copper alloy. Escutcheons shall be either forged copper alloy or CRS. Exposed metal parts, including exposed part under valve handle when in open position, shall have a bright finish.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Fixture Setting: Opening between fixture and floor and wall finish shall be sealed as specified under Section 07 92 00, JOINT SEALANTS. Bio-based materials shall be utilized when possible.

B. Supports and Fastening: Secure all fixtures, equipment and trimmings to partitions, walls and related finish surfaces. Exposed heads of bolts and nuts in finished rooms shall be hexagonal, polished chrome plated brass with rounded tops.

C. Through Bolts: For free standing marble and metal stud partitions refer to Section 10 21 13, TOILET COMPARTMENTS.

D. Toggle Bolts: For hollow masonry units, finished or unfinished.

E. Expansion Bolts: For brick or concrete or other solid masonry. Shall be 6 mm (1/4 inch) diameter bolts, and to extend at least 76 mm (3 inches) into masonry and be fitted with loose tubing or sleeves extending into masonry. Wood plugs, fiber plugs, lead or other soft metal shields are prohibited.

F. Power Set Fasteners: May be used for concrete walls, shall be 6 mm (1/4 inch) threaded studs, and shall extend at least 32 mm (1 1/4 inches) into wall.

G. Tightly cover and protect fixtures and equipment against dirt, water and chemical or mechanical injury.

H. Where water closet waste pipe has to be offset due to beam interference, provide correct and additional piping necessary to eliminate relocation of water closet.

I. Aerators are prohibited on lavatories and sinks.

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

3.2 CLEANING

A. At completion of all work, fixtures, exposed materials and equipment shall be thoroughly cleaned.

3.3 WATERLESS URINAL

A. Manufacturer shall provide an operating manual and onsite training for the proper care and maintenance of the urinals.

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.

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

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09-01-20

SECTION 22 66 00
CHEMICAL-WASTE SYSTEMS PIPING FOR FACILITIES

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section describes the requirements for chemical-waste systems including piping, neutralization equipment, and all necessary accessories as designated in this section.

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

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

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

C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

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

E. Section 07 92 00, JOINT SEALANTS.

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

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

H. Section 22 07 11, PLUMBING INSULATION.

I. 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. Where conflicts occur these specifications and the VHA standards will govern.

B. American Society of Mechanical Engineers (ASME):

A13.1-2015..............Scheme for Identification of Piping Systems

A112.3.1-2007...........Stainless Steel Drainage Systems for Sanitary DWV, Storm, and Vacuum Applications, Above and Below Ground

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

B16.11-2016.............Forged Fittings, Socket-Welding and Threaded

B16.12-2019.............Cast Iron Threaded Drainage Fittings

B16.15-2018.............Cast Copper Alloy Threaded Fittings: Classes 125 and 250

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

A74-2020................Standard Specification for Cast Iron Soil Pipe and Fittings

A183-2014(R2020)........Standard Specification for Carbon Steel Track Bolts and Nuts

A312/A312M-2019.........Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipe

A518/A518M-1999(R2018)..Standard Specification for Corrosion-Resistant High-Silicon Iron Castings

A666-2015...............Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar

A733-2016...............Standard Specification for Welded and Seamless Carbon Steel and Austenitic Stainless Steel Pipe Nipples

A861-2004(R2017)........Standard Specification for High-Silicon Iron Pipe and Fittings

C564-2020a..............Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings

C1036-2016..............Standard Specification for Flat Glass

D2321-2018..............Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications

D2654-2012(R2018).......Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems

D2665-2014..............Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings

D2855-2015..............Standard Practice for the Two-Step (Primer and Solvent Cement) Method of Joining Poly(Vinyl Chloride) (PVC) or Chlorinated Poly(Vinyl Chloride) (CPVC) Pipe and Piping Components with Tapered Sockets

D3222-2018a.............Standard Specification for Unmodified Poly(Vinylidene Fluoride) (PVDF) Molding Extrusion and Coating Materials

D4101-2017e1...........Standard Classification System and Basis for Specification for Polypropylene Injection and Extrusion Materials

E84-2019b...............Standard Test Method for Surface Burning Characteristics of Building Materials

F402-2018...............Standard Practice for Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings

F437-2015...............Standard Specification for Threaded Chlorinated Poly(Vinyl Chloride)(CPVC) Plastic Pipe Fittings, Schedule 80

F493-2014...............Standard Specification for Solvent Cements for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe and Fittings

F1412-2016..............Standard Specification for Polyolefin Pipe and Fittings for Corrosive Waste Drainage Systems

F1673-2010(R2016).......Standard Specification for Polyvinylidene Fluoride (PVDF) Corrosive Waste Drainage Systems

F2618-2019..............Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Pipe and Fittings for Chemical Waste Drainage Systems

D. Cast Iron Soil Pipe Institute (CISPI):

2006....................Cast Iron Soil Pipe and Fittings Handbook, 12th Printing

301-2018................Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications

310-2018................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

E. International Code Council (ICC):

IPC-2018................International Plumbing Code

F. National Electrical Manufacturers Association (NEMA):

250-2018................Enclosures for Electrical Equipment (1000 Volts Maximum)

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

723-2018................Standard for Test for Surface Burning Characteristics of Building Materials

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 66 00, CHEMICAL-WASTE SYSTEMS FOR LABORATORY AND HEALTHCARE FACILITIES”, with applicable paragraph identification.

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

1. Chemical resistant waste and vent piping
2. Cleanouts
3. Floor drains
4. Waterproofing

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

E. Seismic-Design Submittal: For seismic restraints of aboveground piping, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

F. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replaceable parts, and troubleshooting guide:

1. Include complete list indicating all components of the systems.
2. Include complete diagrams of the internal wiring for each item of equipment.

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

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

1.5 QUALITY ASSURANCE

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

1.6 AS-BUILT DOCUMENTATION

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

1.7 PROJECT CONDITIONS

A. Interruption of Existing Chemical-Waste Service: Do not interrupt chemical-waste service to facilities occupied unless permitted under the following conditions and then only after arranging to provide temporary chemical-waste service according to requirements indicated:

1. Provide written notice to COR no fewer than twodays in advance of proposed interruption of chemical-waste service.

2. Do not proceed with interruption of chemical-waste service without COR’s written permission.

PART 2 - PRODUCTS

2.1 CHEMICAL RESISTANT WASTE AND VENT PIPING

A. The material shall include connecting fittings in stacks or mains.

B. The chemical resistant waste and vent piping shall be high silicon iron pipe and drainage pattern fittings conforming to ASTM A518/A518M or ASTM A861. The high silicon cast-iron pipe shall be close grained, bell-and-spigot or beaded-end straight barrel, extra heavy, acid-resistant soil pipe conforming to ASTM A861 containing not less than 14.5 percent silicon content.

1. The joints shall be mechanical joint type constructed of AISI Type 304 corrosion-resistant steel with chloroprene resilient member

supporting a TFE liner ensuring that the liner is the only material wetted by waste stream. Tighten all nuts to a minimum of 9 foot-pounds.

2. The joints shall be bell and Spigot Joint type joint using acid resistant packing and lead calking materials.

C. The chemical resistant waste and vent pipe material shall be Type 316L stainless-steel pipe and drainage pattern fittings conforming to ASME A112.3.1 and ASTM A666. The stainless-steel pipe shall have socket and spigot ends for gasket joints having piping manufacturer’s FPM lip-seal rubber gaskets shaped to fit socket groove with plastic backup ring.

D. Chlorinated Poly (Vinyl Chloride) (CPVC) pipe shall be manufactured from CPVC Type IV, ASTM Cell Classification 23447 and in strict accordance to the requirements of ASTM F2618 for physical dimensions and tolerances and certified by NSF International for corrosive waste end use (NSF-cw). Joining method for pipe and fittings shall be solvent cement welding. Solvent cement shall be a solvent cement specially formulated for resistance to corrosive chemicals and manufactured in accordance with ASTM F493. This pipe shall have a flame spread rating of < 25 and a smoke development rating of < 50 when tested for surface burning characteristics in accordance with ASTM E84 and UL 723 or equivalent.

2.2 PIPING SPECIALTIES

A. High silicon iron dilution traps shall have 38 mm or DN40 to 50 mm or DN50 (NPS 1-1/2 to NPS 2 inches) as required for fixture and waste with mechanical joints and conforming to ASTM A861.

B. Corrosion resistant P-trap or drum trap shall have 38 mm or DN40 to 50 mm or DN50 (NPS 1-1/2 or NPS 2 inches) as required for fixture and waste and conform to ASTM A861 for high silicon iron pipe with hubless joints, ASTM D4101 for polypropylene pipe with mechanical joints.

2.3 CLEANOUTS

A. Cleanouts shall be the same size as the pipe, up to 100 mm or DN100 (NPS 4 inches); not less than 100 mm or DN100 (NPS 4 inches) for larger pipe. Cleanouts for chemical-waste drain pipe shall be of same material as the pipe. Cleanouts shall be easily accessible and shall be gastight and watertight. A minimum clearance of 610 mm (24 inches) shall be provided for clearing a clogged chemical-waste drain.

B. Floor cleanouts shall have cast-iron body and frame with square adjustable scoriated secured nickel bronze top. The cleanout shall be vertically adjustable for a minimum of 50 mm or DN50 (NPS 2 inches). When a waterproof membrane is used in the floor system, a clamping collar 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.

C. Cleanouts shall be provided at or near the base of the vertical stacks with the cleanout plug located approximately 600 mm (24 inches) above the floor. If there are no fixtures installed on the lowest floor, the cleanout shall be installed at the base of the stack. The cleanouts shall be extended to the wall access cover. The vertical cleanout shall consist of sanitary tees. Nickel bronze square frame and stainless-steel cover shall be furnished with a minimum opening of 152 by 152 mm (6 by 6 inches) at each wall cleanout. Where the piping is concealed, a fixture trap or a fixture with integral trap, readily removable without disturbing concealed roughing work, 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/no hub cast-iron ferrule. Plain end (no-hub) piping in interstitial space or above ceiling may use plain end (no-hub) blind plug and clamp.

2.4 FLOOR DRAINS

A. Type L: Flushing Rim Drain. Heavy cast-iron body, double drainage pattern with flushing rim and clamping device. Solid bronze gasketed grate approximately 279 mm (11 inches) in diameter, with 50 mm (2 inch) length of 20 mm or DN20 (NPS 3/4 inch) brass pipe brazed or threaded into the center of the solid grate, pipe shall be threaded and provide brass cap with inter gasket (neoprene) to provide a gas tight installation. Attach deep seal P-trap to drain. Body and trap shall have pipe taps for water supply connections:

1. Drain Flange: Flange for synthetic flooring.

B. Type T: Funnel Type Chemical Resistant Floor Drain and "P" Trap: Double drainage pattern with integral seepage pan for embedding in floor and weep holes to provide adequate drainage from pan to drain pipe. Floor drain shall be polypropylene, flame retardant, Schedule 40 or 80. Provide outlet of floor drain suitable for properly jointing perforated or slotted floor level grate and funnel extension. Cut out grate below funnel. Minimum dimensions as follows:
   1. Height of funnel - 95 mm (3-3/4 inches).
   2. Diameter of lower portion of funnel - 50 mm (2 inches).
   3. Diameter of top portion of funnel - 100 mm (4 inches).

C. Type X: Chemical resistant floor drain and p-trap. Double drainage pattern with integral seepage pan for embedding in floor and weep holes to provide adequate drainage from pan to drain pipe. Floor drain shall be polypropylene, flame retardant, Schedule 40 or 80. Provide outlet of floor drain suitable for properly joining with chemical resistant pipe material.

2.5 WATERPROOFING

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

PART 3 - EXECUTION

3.1 PIPE INSTALLATION

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

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

C. Branch piping for chemical-waste piping system shall be installed and connected to all fixtures, valves, cocks, outlets, casework, cabinets and equipment, including those furnished by the Government or specified in other sections.

D. Piping shall be installed for reagent racks. The piping shall be arranged neatly and located as required by the equipment.

E. Pipe shall be round and straight. Cutting shall be done with proper tools. Pipe, except for plastic and glass, shall be reamed to full size after cutting.

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

G. The piping shall be installed above accessible ceilings to allow for ceiling panel removal.

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

I. The piping shall be installed at the indicated slopes or according to the International Plumbing Code.

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

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

L. Changes in direction for chemical-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.

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

N. 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”.

O. Aboveground CPVC piping shall be installed according to ASTM F2618. Underground CPVC piping shall be installed according to ASTM D2321.

P. Chemical-resistant vent pipe shall be independently vented through the roof.

3.2 JOINT CONSTRUCTION

A. Hub and spigot cast-iron piping with gasket joints shall be joined in accordance with CISPI’s “Cast-Iron Soil Pipe and Fittings Handbook” for compression joints.

B. Hub and spigot cast-iron piping with calked joints shall be joined in accordance with CISPI’s “Cast-Iron Soil Pipe and Fittings Handbook” for lead and oakum calked joints.

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

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

   1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is required by the pipe service.

   2. Pipe sections with damaged threads shall be replaced with new sections of pipe.

E. For PVC piping, solvent cement joints shall be used for joints. All surfaces shall be cleaned and dry prior to applying the primer and solvent cement. Installation practices shall comply with ASTM F402. The joint shall conform to ASTM D2855, ASTM D2654, and ASTM D2665 appendixes.

3.3 SPECIALTY PIPE FITTINGS

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

B. Dielectric fittings shall be installed at connections of dissimilar metal piping and tubing.

C. All chemical-waste piping shall be joined with specialty fittings in accordance with referenced standards and manufacturer’s recommendations for the applications used.

3.4 PIPE HANGERS, SUPPORTS, AND ACCESSORIES

A. All piping shall be supported and labeled according to the International Plumbing Code, Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING, ASME A13.1, and these specifications.

B. Hangers, supports, rods, inserts and accessories used for Pipe supports shall be shop coated with zinc Chromate primer paint. Refer to Section 09 91 00, PAINTING.

C. Horizontal piping and tubing shall be supported within 305 mm (12 inches) of each fitting or coupling.

D. Vinyl coated hangers shall be installed for glass piping. The maximum horizontal spacing and minimum rod diameters shall be:

1. For 25 mm or DN25 to 32 mm or DN32 (NPS 1 to NPS 1-1/4 inches), the maximum spacing shall be 1.22 meters (48 inches) with 10 mm (3/8 inch) rod.
2. For 38 mm or DN40 to 50 mm or DN50 (NPS 1-1/2 to NPS 2 inches), the maximum spacing shall be 1.83 meters (72 inches) with 10 mm (3/8 inch) rod.
3. For 75 mm or DN80 (NPS 3 inches), the maximum spacing shall be 1.83 meters (72 inches) with 13 mm (1/2 inch) rod.
4. For 100 mm or DN100 (NPS 4 inches), the maximum spacing shall be 1.83 meters (72 inches) with 16 mm (5/8 inch) rod.

E. Vertical piping and tubing shall be supported at the base, at each floor, and at intervals no greater than 4.6 meters (15 feet).

F. In addition to the requirements in Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING, floor, Wall and Ceiling Plates, Supports, and 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 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. Hangers and supports utilized with insulated pipe and tubing shall have 180-degree (min.) metal protection shield centered on and welded to the hanger and support. The shield shall be 100 mm (4 inches) in length and be 16-gauge steel. The shield shall be sized for the insulation.

G. Miscellaneous Materials: As specified, required, directed or as noted on the drawings for proper installation of hangers, supports and accessories.

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

I. Penetrations:

1. Where pipes pass through fire partitions, fire walls, smoke partitions, or floors, install a firestop system 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 firestopping materials.
2. At floor penetrations, Clearances around the pipe shall be completely sealed and made watertight with sealant as specified in Section 07 92 00, JOINT SEALANTS.

J. Chemical-waste and vent piping shall conform to the following:

1. Where waste lines from fixtures are shown on plans to be chemical resistant, vents from those fixtures shall also be chemical resistant.
2. Storage and installation for PVDF or CPVC chemical resistant pipe shall comply with ASTM D2665.
3. Glass Pipe installation shall be as recommended by the manufacturer. Glass pipe pitch shall be 1:50 (1/4 inch per foot), minimum.
4. Silver recovery pipe pitch shall be 1:200 (0.5 percent), minimum.
5. Mechanically Joined Polypropylene Pipe requires a pre-grooved pipe or cutting of a groove in each pipe section using a rotation cutting tool. Polypropylene chemical resistant pipe pitch shall be 6 mm (1/4 inch per foot) minimum. Mechanically joined pipe shall not be installed below grade.

6. Plastic chemical-waste pipe shall not be installed within 23 m (75 feet) of hot water appliances (autoclaves, dishwashers, sterilizers) and similar equipment.
7. High silicon content cast-iron pipe with bell and spigot joints and heat fusion plastic pipe may be used below grade under building.
8. Stainless-steel, mechanical joints shall not be installed below grade.
9. Stainless-steel piping system shall be joined and supported per manufacturer's recommendations.

3.5 TESTS

A. The chemical resistant pipe system shall be tested either in its entirety or in sections.

B. Tests for Chemical Resistant Waste and Vent Systems shall be conducted before trenches are backfilled or fixtures are connected. A water test or air test shall be conducted as directed.

1. Entire system is tested using a water test, tightly close all openings in pipes except highest opening, and fill system with water to point of overflow. If system is tested in sections, tightly plug each opening except highest opening of section under test, fill each section with water and test with at least a 3 m (10 foot) head of water. In testing successive sections, test at least upper 3 m (10 feet) of next preceding section so that each joint or pipe except upper most 3 m (10 feet) of system has been submitted to a test of at least a 3 m (10 foot) head of water. Water shall be kept in system, or in portion under test, for at least 15 minutes before inspection starts. System shall then be tight at all joints.
2. 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 1.3 kPa (5 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 STARTUP AND TESTING

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

B. 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 cost or time to the Government.

3.7 COMMISSIONING

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

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

3.8 DEMONSTRATION AND TESTING

A. Provide services of manufacturer’s technical representative for 4hours to instruct each VA personnel responsible in operation and maintenance of the system.

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

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SECTION 22 67 19.16
REVERSE-OSMOSIS WATER EQUIPMENT

PART 1 – GENERAL

1.1 DESCRIPTION

A. Provide complete industrial-type packaged reverse osmosis (RO) water treatment system producing high purity water by removal of dissolved minerals, bacteria, particles and organic impurities. Designed for continuous automatic operation. The system shall include pre-filter, product storage tank and all devices necessary for fully operational system. RO system operation shall be controlled by the water level in the product storage tank.

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

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

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

C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

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

F. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING: Systems for service other than boiler plant make-up water.

G. Section 22 07 11, PLUMBING INSULATION.

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

I. Section 22 31 11, WATER SOFTENERS.

J. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATION.

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 their basic designation only.

B. American Society of Mechanical Engineers (ASME):

B40.100-2013............Pressure Gauges and Gauge Attachments

C. ASTM International (ASTM):

A269/A269M-2014e1.......Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service

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

D. American Water Works Association (AWWA):

B300-2010...............Hypochlorites

B301-2010...............Liquid Chlorine

C651-2014...............Disinfecting Water Mains

E. National Electrical Manufacturers Association (NEMA):

ICS 6-1993 (R2001, R2006) Industrial Control and Systems Enclosures

F. National Fire Protection Association (NFPA):

70-2014.................National Electrical Code

G. Department of Health and Human Services, Food and Drug Administration (FDA):

CFR 21, Chapter 1, Part 175.300, Resinous and Polymeric Coatings

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 67 19.16, REVERSE-OSMOSIS WATER EQUIPMENT”, with applicable paragraph identification.

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

1. Catalog cuts, complete description and specifications of all equipment and accessories.
2. Accessories including filters, product storage tank, pressure gages and test kit.
3. Performance data including normal and maximum flow and pressure drop. Certification that required performance shall be achieved.
4. Piping.

D. Complete detailed layout, setting, arrangement, and installation drawings including. Drawings shall also show all parts of the apparatus including relative positions, dimensions, and sizes and general arrangement of connecting piping.

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

1.5 QUALITY ASSURANCE

A. Manufacturer shall have been engaged in the manufacture of RO systems as a primary product for at least ten years. The ten year requirement supersedes any conflicting requirement in other parts of the project specification.

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.

1.6 PROJECT CONDITIONS

A. Influent Water Analysis:

REFER TO DRAWINGS

Confirm the analysis with current samples and tests.

B. Design Parameters:

REFER TO DRAWINGS.

1.7 AS-BUILT DOCUMENTATION

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

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

C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. As-built drawings are to be provided, and a copy of them in Auto-CAD 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 a certification that all results of tests were within limits specified.

PART 2 - PRODUCTS

2.1 RO SYSTEM

A. Packaged automatic RO system mounted on steel frame, designed for project conditions. Equipment arranged on the frame to allow easy access for operating, maintenance and repair. Unit shall include RO membrane, pressure vessels, pre-filtration system, high pressure pump and all required piping, wiring and controls for a fully operational system.

B. Performance Requirements:

1. Membrane reject ratio: 98 percent minimum. TDS of product is 2 percent maximum of input TDS.
2. Capture rate: 75 percent minimum. Maximum amount of water to drain 25 percent of input.

C. RO Membrane Elements: Thin-film composite with fiberglass reinforced polyester (FRP) over-wrap, anti-telescoping device, u-cup brine seal. The design salt rejection shall be 98 percent based on 2000 ppm water at 1550 kPa (225 psig) at 25 degrees C (77 degrees F).

D. RO Element Housings: Fiberglass with PVC end caps held in place with stainless steel bands. Each housing assembly complete with one set of O-rings and O-ring lubricant. (Bio-based materials shall be utilized when possible.) Housings for systems over 34,070 L per day (9,000 gallons per day) shall be constructed of FRP. Provide cleaning connections.

E. High Pressure Pumps and Motors: Duplex vertical multistage high efficiency centrifugal type with Type 304 stainless steel casing, shaft, impellers. Tungsten carbide and ceramic shaft seals. Cast iron frame with flanged piping connections. Premium efficiency TEFC motor selected to be non-overloading on the entire performance curve.

F. Manual Valves:
   1. Pump Throttle Valve: Type 316 stainless steel ball valve, socket welded.
   2. Concentrate Throttle Valve, Recycle Throttle Valve: In-line needle style, stainless steel, rated for 2070 kPa (300 psig) minimum.
   3. Inlet Isolation Valve, Product and Concentrate Check Valves: PVC with EPDM seats and seals.
   4. Feedwater Sample Valve, Product Water Sample Valve: PVC plug valve with EPDM seats and seals.
   5. High Pressure Sample Valve: Type 316 stainless steel plug valve.

G. Automatic Valves:
   1. Automatic Inlet Shut Off Valve: Solenoid type, diaphragm actuated, normally closed, constructed of glass-filled Noryl thermoplastic.
   2. Automatic Membrane Flush Valve: Provide for purging the membranes with fresh water upon machine shut down.

H. Piping:
   1. Low Pressure Feed, Reject and Recycle Piping 520 kPa (75 psig and under): ASTM D1785, Schedule 80 PVC, socket welded and flanged.
   2. RO Product Tubing From Each Membrane Housing: ASTM D1785, Schedule 80 PVC, socket welded and flanged.
   3. Low Pressure Control and Pressure Gage Tubing: Polyethylene.
   4. High Pressure Reject and Recycle Piping 520 kPa (above 75 psig): ASTM A269/A269M, Type 304 Schedule 10 stainless steel with butt welded joints.
   5. High Pressure Control and Pressure Gage Tubing: 6895 kPa (1000 psig) burst nylon.

I. Controls:
   1. Electronic controller providing automatic control for all operating functions. Motor starter panel. All in FRP enclosures rated NEMA 4. All wiring factory-installed and tested. Comply with Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES and NFPA 70. Provide a pre-installed gateway with the means of transmitting real-time controller readings to Modbus or Bacnet controls.
   2. Autoflush indicator and control to flush RO concentrate at shut down or at predetermined intervals. RO must have a system to flush membranes with Permeate when the RO shuts down.
   3. Warning Alarms: Low quality product, low feed pressure, high feed temperature.
   4. Automatic Shutdowns and Alarms: Low feed pressure, low product quality, pretreatment out of service, storage tank full.
   5. Status Indicators: Low feed pressure, low quality, flow alarm, high feed water temperature, product divert to drain valve open, pretreatment lockout, storage tank full.
   6. Low and High pressure safety switches.
   7. Tank water level control switches.
   8. Pump Motor Starter: Comply with Section 26 29 11, MOTOR CONTROLLERS.
   9. Miscellaneous Controls: Elapsed run time indicator, alarm horn, chemical pump receptacles, convenience receptacles.

J. Instrumentation and Displays:
   1. All instrumentation readouts panel-mounted in FRP enclosures rated NEMA 4. All factory wiring. Comply with NFPA 70.
   2. Digital flow indicators for, product, reject, recycle.
   3. Pressure gages for inlet, cartridge filter outlet, RO feed, RO concentrate, and RO product.
   4. Conductivity indicator measuring product quality with digital displays, alarm relays and automatic temperature compensation.
   5. Conductivity probe mounted in the RO product.

K. Skid and Frame Assembly: RO machine shall be built on a skid and frame constructed of welded structural carbon steel. The entire surface shall be sand-blasted and coated with high solids epoxy coating. Bio-based materials shall be utilized when possible.

L. Reassembly: Unit shall be shipped to the site completely assembled and tested. If units or sections are to be disassembled at the site to allow for installation in a limited space, the unit shall be reassembled and tested for intended operation by a factory authorized technical representative.

2.2 PRE-FILTER

A. Stainless Steel Filter Canister housing designed to hold removable/disposable 5 micron filter elements. Filter housing to be plumbed to RO such that inlet and outlet differential pressure of the housing can be easily viewed at the RO.

2.3 ACTIVATED CARBON FILTER

A. Carbon filter skid sized for the RO machine inlet flow rate. Designed to remove chlorine and chloramines and prevent RO membrane damage.

B. Media Tank: FRP designed for 1035 kPa (150 psig). Pre-piped internal backwash distributor and filtered water collector.

C. Filter Media: 12 x 40 mesh bituminous coal-based activated carbon. Install media at job site.

D. Backwash Cycle: Top-mounted, piston-operated control valve with pre-sized drain line flow control orifice. The cycle shall be initiated by and adjustable seven day electronic time clock or may be triggered by water meter. The valve(s) must have the capability to operate as single, alternating or progressive, depending on flow rates. Include RO lockout switch.

2.4 RO WATER STORAGE TANK

A. Free-standing, closed-top, conical-bottom268 cubic feet (2000 gallons) total volume. Top access manway, PVC bulkhead fittings for high and low level alarm switches, RO permeate inlet, RO permeate discharge, emergency overflow, and drain. Install 0.2 micron tank vent filter at the top head. Vented to atmosphere.

B. Materials of Construction: Linear polyethylene in one piece, black or green in color Tank must have sight gauge or tube for viewing of water level.

C. Tank Water Level Control: Adjustable float switch that signal starting and stopping RO pump. High and low level alarm switches.

2.5 PRESSURE GAGES

A. ASME B40.100, Grade A, 1 percent accuracy, 115 mm (4-1/2 inches) diameter, all metal case, bottom connected. White dials, black hands, graduated from 0 to 690 kPa (0 to 100 psig) and identity labeled.

2.6 WATER TESTING EQUIPMENT

A. Furnish water testing equipment in a portable cabinet specially made for the installed equipment. Include sufficient materials for 6 months of normal testing procedures.

B. Silt Density Index (SDI) apparatus to measure degree of suspended solids feeding the RO membranes. Include pressure regulator, pressure gage, filter holder, 600 mL (20 ounce) beaker, sample valve, tubing and 0.45 micron filter papers.

C. Test kit to measure total water hardness, total iron, free chlorine, pH.

PART 3 – EXECUTION

3.1 REQUIRED TECHNICAL SERVICES

A. Provide services of a qualified manufacturer's representative to check complete installation for conformance to manufacturer's recommendations, put system into service, make all adjustments required for full conformance to design and specified requirements, and perform all demonstrations and tests.

3.2 FLUSHING AND DISINFECTING

A. Flush and disinfect new water lines and RO system and tank interiors in accordance with AWWA C651.

B. Material:

1. Liquid chlorine: AWWA B301.
2. Hypochlorite: AWWA B300.

3.3 STARTUP AND TESTING

A. Operating: Tests shall be run in presence of COR.

B. Procedure:

1. Operate RO system at constant maximum required capacity for one hour after RO product water is produced. When necessary, waste product water to sewer to maintain above flow rate. Product water production shall begin when a sample shows that RO permeate complies with requirements.

2. Demonstrate all features of the control system including diagnostics and flow and cycle indications.

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

3.4 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.

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

3.5 MAINTENANCE SERVICE

A. Provide full maintenance contract by service technician of water softener manufacturers, including preventative maintenance as required for proper operation of reverse osmosis equipment. Servicing company shall be within 2 hours drive and be capable of responding within 6 to 8 hours.

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SECTION 23 05 10
COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. The requirements of this Section apply to all sections of Division 23 related to boiler plant and steam generation.

B. Definitions:

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

C. Abbreviations/Acronyms:

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

25. CPM: Cycles Per Minute
26. CPVC: Chlorinated Polyvinyl Chloride
27. CRS: Corrosion Resistant Steel
28. CTPD: Condensate Transfer Pump Discharge
29. CTPS: Condensate Transfer Pump Suction
30. CW: Cold Water
31. CWP: Cold Working Pressure
32. CxA: Commissioning Agent
33. dB: Decibels
34. dB(A): Decibels (A weighted)
35. DDC: Direct Digital Control
36. DI: Digital Input
37. DO: Digital Output
38. DVD: Digital Video Disc
39. DN: Diameter Nominal
40. DWV: Drainage, Waste and Vent
41. EPDM: Ethylene Propylene Diene Monomer
42. EPT: Ethylene Propylene Terpolymer
43. ETO: Ethylene Oxide
44. F: Fahrenheit
45. FAR: Federal Acquisition Regulations
46. FD: Floor Drain
47. FED: Federal
48. FG: Fiberglass
49. FGR: Flue Gas Recirculation
50. FOS: Fuel Oil Supply
51. FOR: Fuel Oil Return
52. FSK: Foil-Scrim-Kraft facing
53. FWPD: Feedwater Pump Discharge
54. FWPS: Feedwater Pump Suction
55. GC: Chilled Glycol Water Supply
56. GCR: Chilled Glycol Water Return
57. GH: Hot Glycol Water Heating Supply
58. GHR: Hot Glycol Water Heating Return
59. gpm: Gallons Per Minute
60. HDPE: High Density Polyethylene

61. Hg: Mercury
62. HOA: Hands-Off-Automatic
63. hp: Horsepower
64. HPS: High Pressure Steam (equal to/greater than 414 kPa (60 psig))
65. HPR: High Pressure Steam Condensate Return
66. HW: Hot Water
67. HWH: Hot Water Heating Supply
68. HWHR: Hot Water Heating Return
69. Hz: Hertz
70. ID: Inside Diameter
71. IPS: Iron Pipe Size
72. kg: Kilogram
73. klb: 1000 lb
74. kPa: Kilopascal
75. lb: Pound
76. lb/hr: Pounds Per Hour
77. L/s: Liters Per Second
78. L/min: Liters Per Minute
79. LPS: Low Pressure Steam (equal to/less than 103 kPa (15 psig))
80. LPR: Low Pressure Steam Condensate Gravity Return
81. MAWP: Maximum Allowable Working Pressure
82. MAX: Maximum
83. MBtu/h: 1000 Btu/h
84. MBtu: 1000 Btu
85. MED: Medical
86. m: Meter
87. MFG: Manufacturer
88. mg: Milligram
89. mg/L: Milligrams Per Liter
90. MIN: Minimum
91. MJ: Megajoules
92. ml: Milliliter
93. mm: Millimeter
94. MPS: Medium Pressure Steam (110-414 kPa [16-60 psig])
95. MPR: Medium Pressure Steam Condensate Return
96. MW: Megawatt

97.NC: Normally Closed

98.NF: Oil Free Dry (Nitrogen)

99.Nm: Newton Meter

100.NO: Normally Open

101.NOx: Nitrous Oxide

102.NPT: National Pipe Thread

103.NPS: Nominal Pipe Size

104.OD: Outside Diameter

105.OSD: Open Sight Drain

106.OS&Y: Outside Stem and Yoke

107.PC: Pumped Condensate

108.PID: Proportional-Integral-Differential

109.PLC: Programmable Logic Controllers

110.PP: Polypropylene

111.PPE: Personal Protection Equipment

112.ppb: Parts Per Billion

113.ppm: Parts Per Million

114.PRV: Pressure Reducing Valve

115.PSIA: Pounds Per Square Inch Absolute

116.psig: Pounds Per Square Inch Gauge

117.PTFE: Polytetrafluoroethylene

118.PVC: Polyvinyl Chloride

119.PVDC: Polyvinylidene Chloride Vapor Retarder Jacketing, White

120.PVDF: Polyvinylidene Fluoride

121.rad: Radians

122.RH: Relative Humidity

123.RO: Reverse Osmosis

124.rms: Root Mean Square

125.RPM: Revolutions Per Minute

126.RS: Refrigerant Suction

127.RTD: Resistance Temperature Detectors

128.RTRF: Reinforced Thermosetting Resin Fittings

129.RTRP: Reinforced Thermosetting Resin Pipe

130.SCFM: Standard Cubic Feet Per Minute

131.SPEC: Specification

132.SPS: Sterile Processing Services

133. STD: Standard
134. SDR: Standard Dimension Ratio
135. SUS: Saybolt Universal Second
136. SW: Soft water
137. SWP: Steam Working Pressure
138. TAB: Testing, Adjusting, and Balancing
139. TDH: Total Dynamic Head
140. TEFC: Totally Enclosed Fan-Cooled
141. TFE: Tetrafluoroethylene
142. THERM: 100,000 Btu
143. THHN: Thermoplastic High-Heat Resistant Nylon Coated Wire
144. THWN: Thermoplastic Heat & Water-Resistant Nylon Coated Wire
145. T/P: Temperature and Pressure
146. USDA: U.S. Department of Agriculture
147. V: Volt
148. VAC: Vacuum
149. VA: Veterans Administration
150. VAC: Voltage in Alternating Current
151. VA CFM: VA Construction & Facilities Management
152. VA CFM CSS: Consulting Support Service
153. VAMC: Veterans Administration Medical Center
154. VHA OCAMES: Veterans Health Administration – Office of Capital Asset Management Engineering and Support
155. VR: Vacuum condensate return
156. WCB: Wrought Carbon Steel, Grade B
157. WG: Water Gauge or Water Column
158. 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 91 00, GENERAL COMMISSIONING REQUIREMENTS.
E. Section 02 82 11, TRADITIONAL ASBESTOS ABATEMENT.
F. Section 03 30 00, CAST-IN-PLACE CONCRETE.
G. Section 05 31 00, STEEL DECKING.
H. Section 05 36 00, COMPOSITE METAL DECKING.

I. Section 05 50 00, METAL FABRICATIONS.
J. Section 07 60 00, FLASHING AND SHEET METAL.
K. Section 07 84 00, FIRESTOPPING.
L. Section 07 92 00, JOINT SEALANTS.
M. Section 09 91 00, PAINTING.
N. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.
O. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT.
P. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
Q. Section 23 05 51, NOISE AND VIBRATION CONTROL FOR BOILER PLANT.
R. Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.
S. Section 23 07 11, HVAC AND BOILER PLANT INSULATION.
T. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
U. Section 23 08 11, DEMONSTRATIONS AND TESTS FOR BOILER PLANT.
V. Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.
W. Section 23 21 11, BOILER PLANT PIPING SYSTEMS.
X. Section 23 50 11, BOILER PLANT MECHANICAL EQUIPMENT.
Y. Section 23 52 39, FIRE-TUBE BOILERS.
Z. Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.
AA. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES.
BB. Section 26 29 11, MOTOR CONTROLLERS.
CC. Section 33 63 00, STEAM ENERGY DISTRIBUTION.

1.3 APPLICABLE PUBLICATIONS

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

B. Air Movement and Control Association (AMCA):

410-1996................Recommended Safety Practices for Users and Installers of Industrial and Commercial Fans

C. American Society of Mechanical Engineers (ASME):

B31.1-2014..............Power Piping

B31.9-2014..............Building Services Piping

ASME Boiler and Pressure Vessel Code:

BPVC Sec I-2019.........Rules for Construction of Power Boilers

BPVC Sec IX-2019........Welding, Brazing, and Fusing Qualifications

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

A36/A36M-2017...........Standard Specification for Carbon Structural Steel

A575-2018...............Standard Specification for Steel Bars, Carbon, Merchant Quality, M-Grades

E. Association for Rubber Products Manufacturers (ARPM):

IP-20-2015..............Specifications for Drives Using Classical V-Belts and Sheaves

IP-21-2016..............Specifications for Drives Using Double-V (Hexagonal) Belts

F. International Code Council, (ICC):

IMC-2018................International Mechanical Code

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

SP-58-2018..............Pipe Hangers and Supports-Materials, Design, Manufacture, Selection, Application, and Installation

SP-127-2014a............Bracing for Piping Systems: Seismic-Wind-Dynamic Design, Selection, and Application

H. Military Specifications (MIL):

MIL-P-21035B-2003.......Paint High Zinc Dust Content, Galvanizing Repair (Metric)

I. National Fire Protection Association (NFPA):

31-2019.................Standard for Installation of Oil-Burning Equipment

54-2018.................National Fuel Gas Code

70-2017.................National Electrical Code (NEC)

85-2019.................Boiler and Combustion Systems Hazards Code

101-2018................Life Safety Code

J. Department of Veterans Affairs (VA):

........................VHA Boiler Plant Safety Devices Testing Manual, Fifth Edition

PG-18-10-2016...........Steam, Heating Hot Water, and Outside Distribution Systems Design Manual

PG-18-10-2011...........Asbestos Abatement Design Manual

PG-18-10-2014...........Sustainable Design Manual

PG-18-10-2016...........Physical Security and Resiliency Design Manual

1.4 SUBMITTALS

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

B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION", with applicable paragraph identification.

C. All submittals in these sections are for equipment and materials that are interdependent parts of the entire systems; therefore, they shall all be submitted at the same time and complete including coordination/shop drawings, installation instructions, structural support, and structural piping calculations so that they may be reviewed as a system. The submittals for each Section shall be covered by one individual transmittal signed by the prime Contractor and containing a statement that the Contractor has fully reviewed all documents. Deviations from the contract documents, if any, shall be listed on the transmittal.

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

E. Test Plans: Submit safety test plan for temporary steam plant with temporary steam plant submittals. Submit all other test plans for plant and equipment 45 days prior to start of testing to allow for test modifications prior to start.

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

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

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

I. Submittals and shop drawings for interdependent items, containing applicable descriptive information, shall be furnished together. Coordinate and properly integrate materials and equipment to provide a completely compatible and efficient installation.

J. 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.

K. Coordination/Shop Drawings:

1. Submit complete consolidated and coordinated shop drawings for all new systems, and for existing systems that are in the same areas.
2. The coordination/shop drawings shall include plan views, elevations and sections of all systems and shall be on a scale of not less than

1:32 (3/8-inch equal to one foot). Clearly identify and dimension the proposed locations of the principal items of equipment. The drawings shall clearly show locations and adequate clearance for all equipment, piping, valves, control panels and other items. Show the access means for all items requiring access for operations and maintenance. Provide detailed coordination/shop drawings of all piping and duct systems. The drawings should include all lockout/tagout points for all energy/hazard sources for each piece of equipment. Coordinate lockout/tagout procedures and practices with local VA requirements.

3. Do not install equipment foundations, equipment or piping until coordination/shop drawings have been approved.
4. In addition, for HVAC systems, provide details of the following:
   a. Mechanical equipment rooms.
   b. Hangers, inserts, supports, and bracing.
   c. Pipe sleeves.
   d. Duct or equipment penetrations of floors, walls, ceilings, or roofs.

L. Manufacturer's Literature and Data: Include full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity. Submit under the pertinent section rather than under this section.

1. Submit belt drive with the driven equipment. Submit selection data for specific drives when requested by the COR.
2. Submit electric motor data and variable speed drive data with the driven equipment.
3. Equipment and materials identification.
4. Fire-stopping materials.
5. Hangers, inserts, supports and bracing. Provide complete stress analysis for variable spring and constant support hangers. For boiler plants, refer to Section 23 21 11, BOILER PLANT PIPING SYSTEMS, for additional requirements.
6. Wall, floor, and ceiling plates.

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

N. Maintenance Data and Operating Instructions:
   1. Maintenance and operating manuals in accordance with Section 01 00 00, GENERAL REQUIREMENTS, paragraph, INSTRUCTIONS, for systems and equipment.
   2. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replacement parts, and troubleshooting guide:
      a. Include complete list indicating all components of the systems.
      b. Include complete diagrams of the internal wiring for each item of equipment.
      c. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.
   3. Provide a listing of recommended replacement parts for keeping in stock supply, including sources of supply, for equipment. Include in the listing belts for equipment: Belt manufacturer, model number, size and style, and distinguished whether of multiple belt sets.

O. Boiler Plant Maintenance Data and Operating Instructions:
   1. Provide 4 bound copies or 2 electronic versions on CD . Deliver to COR not less than 30 days prior to completion of a phase or final inspection.
   2. Include all new and temporary equipment and all elements of each assembly.
   3. Data sheet on each device listing model, size, capacity, pressure, speed, horsepower, pump impeller size, other data.
   4. Manufacturer’s installation, maintenance, repair, and operation instructions for each device. Include assembly drawings and parts lists. Include operating precautions and reasons for precautions.
   5. Lubrication instructions including type and quantity of lubricant.
   6. Schematic diagrams and wiring diagrams of all control systems corrected to include all field modifications.
   7. Description of boiler firing and operating sequence including description of relay and interlock positions at each part of the sequence.
   8. Set points of all interlock devices.

9. Trouble-shooting guide for control systems.
10. Operation of the combustion control system.
11. Emergency procedures.
12. Control system programming information for parameters, such as set points, that do not require services of an experienced technician.
13. Step-by-Step written instructions that are specific for the system installed on testing all safety devices. The instructions should be in the same format and in compliance and equivalent to the VHA Boiler Plant Safety Devices Testing Manual for each test. All safety devices listed in the manual shall be tested and documentation provided certifying completion.

P. Provide copies of approved HVAC equipment submittals to the TAB and Commissioning Subcontractor.
Q. Completed System Readiness Checklist provided by the Commissioning Agent and completed by the Contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
R. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

1.5 QUALITY ASSURANCE

A. Mechanical, electrical and associated systems shall be safe, reliable, efficient, durable, easily and safely operable and maintainable, easily and safely accessible, and in compliance with applicable codes as specified. All VA safety device requirements shall be complied with regardless of the size, type, or operating pressure of boiler to include condensing boilers, hot water boilers for heating systems, as defined in the VHA Boiler Plant Safety Devices Testing Manual. The systems shall be comprised of high quality institutional-class and industrial-class products of manufacturers that are experienced specialists in the required product lines. All construction firms and personnel shall be experienced and qualified specialists in industrial and institutional HVAC or steam boiler plant construction, as applicable.
B. Flow Rate Tolerance for HVAC Equipment: Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.

C. Equipment Vibration Tolerance: Refer to Section 23 05 51, NOISE AND VIBRATION CONTROL FOR BOILER PLANT. Equipment shall be factory-balanced to this tolerance and re-balanced on site, as necessary.

D. Products Criteria:

1. Standard Products: Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products for at least 3 years (or longer as specified elsewhere). The design, model and size of each item shall have been in satisfactory and efficient operation on at least three installations for approximately three years. However, digital electronics devices, software and systems such as controls, instruments, computer work station, shall be the current generation of technology and basic design that has a proven satisfactory service record of at least three years. See other specification sections for any exceptions and/or additional requirements.
2. Refer to all other sections for quality assurance requirements for systems and equipment specified therein.
3. All items furnished shall be free from defects that would adversely affect the performance, maintainability and appearance of individual components and overall assembly.
4. The products and execution of work specified in Division 33 shall conform to the referenced codes and standards as required by the specifications. Local codes and amendments shall be enforced, along with requirements of local utility companies. The most stringent requirements of these specifications, local codes, or utility company requirements shall always apply. Any conflicts shall be brought to the attention of the COR.
5. Multiple Units: When two or more units of materials or equipment of the same type or class are required, these units shall be of the same manufacturer and model number, or if different models are required, they shall be of the same manufacturer and identical to the greatest extent possible (i.e., same model series).
6. Assembled Units: Performance and warranty of all components that make up an assembled unit shall be the responsibility of the manufacturer of the completed assembly.

7. Nameplates: Nameplate bearing manufacturer's name or identifiable trademark shall be securely affixed in a conspicuous place on equipment, or name or trademark cast integrally with equipment, stamped or otherwise permanently marked on each item of equipment.
8. Use of asbestos products or equipment or materials containing asbestos is prohibited.

E. Boiler Plant Equipment Service Providers: Service providers shall be authorized and trained by the manufacturers of the equipment supplied. These providers shall be capable of responding onsite and provide acceptable service to restore boiler plant operations within 4 hours of receipt of notification by phone, e-mail or fax in event of an emergency, such as the shutdown of equipment; or within 24 hours in a non-emergency. Submit names, mail and e-mail addresses and phone numbers of service personnel and companies providing service under these conditions for (as applicable to the project): burners, burner control systems, boiler control systems, pumps, critical instrumentation, computer workstation and programming.

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

G. Boiler Plant and Outside Steam Distribution Welding: Refer to Section 23 21 11, BOILER PLANT PIPING SYSTEMS and Section 33 63 00, STEAM ENERGY DISTRIBUTION.

H. Manufacturer's Recommendations: Where installation procedures or any part thereof are required to be in accordance with the recommendations of the manufacturer of the material being installed, printed copies of these recommendations shall be furnished to the COR with submittals.

Installation of the item will not be allowed to proceed until the recommendations are received. Failure to furnish these recommendations can be cause for rejection of the material and removal by the Contractor and no additional cost or time to the Government.

I. Execution (Installation, Construction) Quality:
   1. Apply and install all items in accordance with manufacturer's written instructions. Refer conflicts between the manufacturer's instructions and the contract documents to the COR for resolution. Provide written hard copies and computer files on CD or DVD of manufacturer’s installation instructions to the COR with submittals prior to commencing installation of any item. Installation of the item will not be allowed to proceed until the recommendations are received and approved by VA. Failure to furnish these recommendations is a cause for rejection of the material.
   2. All items that require access, such as for operating, cleaning, servicing, maintenance, and calibration, shall be easily and safely accessible by persons standing at floor level, or standing on permanent platforms, without the use of portable ladders. Examples of these items include but are not limited to: all types of valves, filters and strainers, transmitters, control devices. Prior to commencing installation work, refer conflicts between this requirement and contract documents to the COR for resolution. Failure of the Contractor to resolve or point out any issues will result in the Contractor correcting at no additional cost or time to the Government.
   3. Complete coordination/shop drawings shall be required in accordance with paragraph, SUBMITTALS. Construction work shall not start on any system until the coordination/shop drawings have been approved by VA.
   4. Workmanship/craftsmanship will be of the highest quality and standards. The VA reserves the right to reject any work based on poor quality of workmanship this work shall be removed and done again at no additional cost or time to the Government.

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

K. Guaranty: Warranty of Construction, FAR Clause 52.246-21.

1.6 DELIVERY, STORAGE AND HANDLING

A. Protection of Equipment:

1. Equipment and material placed on the job site shall remain in the custody of the Contractor until phased acceptance, whether or not the Government has reimbursed the Contractor for the equipment and material. The Contractor is solely responsible for the protection of such equipment and material against any damage or theft.
2. Large equipment such as boilers, tanks, economizers, heat exchangers, and fans if shipped on open trailer trucks shall be covered with shrink on plastics or waterproof tarpaulins that provide protection from exposure to rain, road salts and other transit hazards. Protection shall be kept in place until equipment is moved into a building or installed as designed.
3. Repair damaged equipment in first class, new operating condition and appearance; or replace same as determined and directed by the COR. Such repair or replacement shall be at no additional cost or time to the Government.
4. Protect interiors of new equipment and piping systems against entry of foreign matter. Clean both inside and outside before painting or placing equipment in operation.
5. Existing equipment and piping being worked on by the Contractor shall be under the custody and responsibility of the Contractor and shall be protected as required for new work.
6. Protect plastic piping and tanks from ultraviolet light (sunlight).

B. Cleanliness of Piping and Equipment Systems:

1. Exercise care in storage and handling of equipment and piping material to be incorporated in the work. Remove debris arising from cutting, threading and welding of piping.
2. Piping systems shall be flushed, blown or pigged as necessary to deliver clean systems.
3. Clean interior of all tanks prior to delivery for beneficial use by the Government.
4. Boilers shall be left clean following final internal inspection by Government insurance representative or inspector.

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

1.7 AS-BUILT DOCUMENTATION

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

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

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

D. As-built drawings are to be provided, with a copy of them on AutoCAD provided on CD/DVD. The CAD drawings shall use multiple line layers with a separate individual layer for each system.The as-built drawings shall indicate the location and type of all lockout/tagout points for all energy sources for all equipment and pumps to include breaker location and numbers, valve tag numbers, etc. Coordinate lockout/tagout procedures and practices with local VA requirements.

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

1.8 JOB CONDITIONS – WORK IN EXISTING BOILER PLANT

A. Plant Operation: Government employees will be continuously operating and managing all plant facilities, including temporary facilities, that serve the steam, condensate, and hot water requirements of the VAMC.

B. Maintenance of Steam Supply and Condensate Return Service: Schedule all work to permit continuous steam and condensate service at pressures and flow rates as required by the VAMC. At all times, there shall be one spare boiler available and one spare pump for each service available, in addition to those required for serving the load demand. The spare boiler and pumps must be capable of handling the loads that may be imposed if the operating boiler or pump fails.

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 steam demands are not critical to the operation of the VAMC. These non-critical periods are limited to between 8 pm and 5 am during the non-heating season. Provide at least 10 working days advance notice to the COR. The request shall include a detailed plan on the proposed shutdown and the intended work to be done along with manpower levels. All equipment and materials must be onsite and verified with plan 5 days prior to the shutdown or it will need to be rescheduled.

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

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

F. Acceptance of Work for Government Operation: As new equipment, systems and facilities are made available for operation and these items are deemed of beneficial use to the Government, inspections will be made, and tests will be performed. Based on the inspections, a list of contract deficiencies will be issued to the Contractor. No boiler, system, or piece of equipment will be accepted for beneficial use until ALL safety devices have been tested and passed in accordance with the VHA Boiler Plant Safety Devices Testing Manual; all equipment that requires regular maintenance, calibration, etc. are accessible from the floor or permanent work platform; and all control systems are proven to be fully operational without faults or shutdowns for a period not less than 21 days of continuous operation without interaction from any person other than that of normal operational duty. 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 paragraph, TEMPORARY PIPING AND EQUIPMENT in this section.

PART 2 - PRODUCTS

2.1 FACTORY-ASSEMBLED PRODUCTS

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

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

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

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

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

D. Major items of equipment, which serve the same function, must be the same make and model. Exceptions must be approved by the VA but may be permitted if performance requirements cannot be met.

2.2 COMPATIBILITY OF RELATED EQUIPMENT

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

2.3 BELT DRIVES

A. Type: ARPM standard V-belts with proper motor pulley and driven sheave. Belts shall be constructed of reinforced cord and rubber.

B. Dimensions, rating and selection standards: ARPM IP-20 and ARPM IP-21.

C. Minimum Horsepower Rating: Motor horsepower plus recommended ARPM service factor (not less than 20 percent) in addition to the ARPM allowances for pitch diameter, center distance, and arc of contact.

D. Maximum Speed: 25 m/s (5000 feet per minute).

E. Adjustment Provisions: For alignment and ARPM standard allowances for installation and take-up.

F. Drives may utilize a single V-Belt (any cross section) when it is the manufacturer's standard.

G. Multiple Belts: Matched to ARPM specified limits by measurement on a belt measuring fixture. Seal matched sets together to prevent mixing or partial loss of sets. Replacement, when necessary, shall be an entire set of new matched belts.

H. Sheaves and Pulleys:
   1. Material: Pressed steel, or close-grained cast iron.
   2. Bore: Fixed or bushing type for securing to shaft with keys.
   3. Balanced: Statically and dynamically.
   4. Groove spacing for driving and driven pulleys shall be the same.
   5. Minimum Diameter of V-Belt Sheaves (ARPM recommendations) in millimeters and inches:

I. Drive Types, Based on ARI 435:
   1. Provide adjustable pitch drive as follows:
      a. Fan speeds up to 1800 RPM: 7.5 kW (10 hp) and smaller.
      b. Fan speeds over 1800 RPM: 2.2 kW (3 hp) and smaller.
   2. Provide fixed-pitch drives for drives larger than those listed above.
   3. The final fan speeds required to just meet the system CFM and pressure requirements, without throttling the design air flow branch, shall be determined by adjustment of a temporary adjustable-pitch motor sheave or by fan law calculation if a fixed-pitch drive is used initially.

J. Final Drive Set: If adjustment is required beyond the capabilities of the factory drive set, the final drive set shall be provided as part of this contract at no additional cost or time to the Government.

2.4 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-gauge sheet steel; all edges shall be hemmed and ends shall be bent into flanges and the flanges 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, and non-resonant. Guard shall be an assembly of minimum 22-gauge sheet steel and expanded or perforated metal to permit observation of belts. 25 mm (1 inch) diameter hole shall be provided at each shaft centerline to permit speed measurement.

D. Materials: Sheet steel, 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 (1 inch) diameter hole at each shaft center.

2.5 LIFTING ATTACHMENTS

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

2.6 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, MOTOR CONTROLLERS; and, Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES. Provide all electrical wiring, conduit, and devices necessary for the proper connection, protection and operation of the systems. Provide special energy efficient premium efficiency type motors as scheduled.

2.7 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. Coordinate variable speed motor controllers’ communication protocol with Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.

C. Provide variable speed motor controllers with or without a bypass contactor as indicated in Contract drawings.

D. 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., pumps shall be product of a single manufacturer.

E. 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.

F. 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.

2.8 TEMPORARY BOILER PLANT INSTALLATION

A. Provide temporary facilities to replace all functions of the existing boiler plant during the construction period. Temporary facilities must remain in operation until all new facilities are accepted for beneficial use. Temporary facilities shall provide same quality and capacity of service as existing facilities.

B. Refer to contract documents for arrangement and location of temporary facilities and for equipment performance requirements.

C. Temporary equipment may be new or previously used. Previously used equipment shall show no evidence of wear or deterioration that would affect the safe, reliable operation.

D. Equipment to be utilized in the new plant shall not be used in the temporary plant.

E. Remove all temporary facilities from Government property after final use. Provide COR 10 working days advance notice prior to removal.

F. Equipment must be clean inside and outside.

G. Boilers and accessories shall have the following:

1. Design pressure exceeding maximum safety valve set pressure.
2. Construction and accessories in compliance with ASME Boiler and Pressure Vessel Code, Section I.
3. After installation and prior to operation, provide internal inspection by authorized inspector certified by National Board of Boiler and Pressure Vessel Inspectors. Submit signed report to COR. Inspector must certify boilers as clean and safe for operation. Photographic evidence shall be taken of the condition of the boiler internally of both the water and fire sides at time of delivery and prior to operation and once again when the prior to the temporary

boiler leaving the site. This is to ensure the VA is not charged to descale the boilers.

4. Steam output flow range and pressure as shown on contract documents.
5. Dual low water cutoffs, dual high steam pressure cutouts, high water alarm.
6. Calibrated steam pressure gauge, 150 mm (6 inch) minimum diameter.
7. One set of spares for all gaskets and water column gauge glasses.
8. Provide N+1 capacity.
9. Equip with all safety devices defined and tested in accordance with the VHA Boiler Plant Safety Devices Testing Manual at the Contractor’s expense.
10. Emergency power connection for continuous operation during utility outage.

H. Burners, accessories, and fuel trains shall have the following:
   1. Automatic operation over entire firing range. Turndown capability 6/1 or greater.
   2. Comply with NFPA 85 regardless of burner input rating.
   3. All safety devices UL listed for the service and defined in the VHA Boiler Plant Safety Devices Testing Manual.
   4. Dual fuel capability.
   5. Filtration devices at entrance to each fuel train designed to protect all downstream devices from clogging or plugging.
   6. Pressure regulating valves on main gas and igniter (pilot) gas.
   7. Pressure gauges at burners and outlets of pressure regulating valves.
   8. One set of spare drive belts for all belt-driven equipment.

I. Burner control (Flame Safeguard) system shall have the following:
   1. Automatic operation, self-checking circuits.
   2. UL listed, FM approved.
   3. Self-checking ultraviolet flame detectors. Infrared flame detectors with self-checking amplifiers permitted on fire tube boilers.
   4. Provide one spare scanner and control chassis for each type utilized.

J. Combustion Control System: Automatic control of steam pressure, with provision for manual control.

K. Feedwater System:
   1. Provide system, including feedwater deaerator, to furnish minimum water temperature of 104 degrees C (220 degrees F), pressure and quality recommended by boiler manufacturer. Maximum oxygen content of feedwater from deaerator 12 ppb.
   2. Capacity shall exceed maximum steam flow requirement of VAMC.
   3. Provide automatic feedwater deaerator water level control and high and low-level alarms as defined in the VHA Boiler Plant Safety Devices Testing Manual.
   4. Provide one full size redundant feed pump.
   5. Automatic boiler water level control with three-valve bypass.
   6. Automatic water softener for make-up water.
   7. Prior to operation, provide internal inspection of feedwater deaerator by Authorized Inspector certified by the National Board of Boiler and Pressure Vessel Inspectors. Submit signed report. Inspector must certify deaerator as clean and safe for operation.

L. Instrumentation:
   1. Record steam flow rate and provide totalizer for each boiler.
   2. Pressure gauge for main steam header, feedwater header, fuel oil and natural gas headers.
   3. Mount recorders and pressure gauges in painted, reinforced sheet metal panel.
   4. Provide 100 recorder charts of each type and two replacement recorder pens for each pen arm.

M. Chemical Treatment System: Provide individual pump type systems to deliver proper chemicals to each boiler. Water quality shall be maintained as directed by contractor-retained water treatment firm. All chemicals must be FDA approved for use where steam contacts food or is used for humidification. Provide chemical treatment, or maintain existing chemical treatment, which protects all site coils and condensate lines from corrosion.

N. Blowoff System: Provide system to collect boiler bottom blowoff and to discharge it to sanitary sewer at temperature not exceeding 65 degrees C (150 degrees F).

O. Fuel System: Provide systems to furnish sufficient natural gas and No. 2 fuel oil to generate steam to satisfy maximum steam flow demand of

VAMC. Comply with NFPA 31 and NFPA 54. Provide filtration systems to protect pumps, flow meters, and pressure control valves. Fuel oil systems shall operate with no air entrainment or pump cavitation.

P. Access Platforms and Ladders: Provide for access to all valves, controls and instruments not accessible to personnel standing on floor. Design of platforms and ladders must comply with OSHA requirements.

Q. Enclosure of Temporary Equipment: Provide clean, dry, ventilated, lighted, heated shelter for all equipment and for operating personnel. Heating system shall maintain 18 degrees C (65 degrees F) under all weather conditions and when boilers are not in operation. Shelter construction must comply with all state and local codes.

R. Provisions shall be made for operators control room within the line of sight and adjacent to the temporary equipment to allow 24/7 oversight of the systems. This will include appropriate break and restroom facilities.

S. Pipe, Stack, and Breeching Supports: Support all hot systems on roller and spring hangers. Anchor and support all systems in compliance with recommendations and requirements of ASME B31.1 and MSS SP-58.

T. Pipe, Equipment, Boiler Stack and Breeching Insulation: Provide material and thickness as specified for permanent installation, except maximum thickness shall be 50 mm (2 inches) and all pipe insulation may be fiberglass with all-service jackets.

U. Power Supply: Provide full time power and emergency power to serve full load operation of all equipment in temporary boiler plant.

V. Repairs and Maintenance: Contractor shall furnish labor and material for all repairs and safety device testing at no additional cost or time to the Government. Malfunctions that reduce the steam supply to the facility shall be repaired within 4 hours of notice. Other repairs shall be accomplished within 24 hours of notice. Routine maintenance requiring standard tools and supplies and less than one man-hour per day will be performed by the Government. Cleaning made necessary by Government operation will be performed by the Government.

W. Seismic Anchorage of Equipment and Bracing of Piping, Stacks, Breeching: Conform to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

2.9 EQUIPMENT AND MATERIALS IDENTIFICATION

A. Attach a tag to all mechanical equipment, including but not limited to, boilers, deaerator, surge tank, pumps, steam traps, tanks, etc. Note all equipment tag numbers on contractor / as-built redline drawings. Use symbols, nomenclature and equipment numbers specified, shown on the contract documents and shown in the maintenance manuals. In addition, provide bar code identification nameplate for all equipment which will allow the equipment identification code to be scanned into the system for maintenance and inventory tracking. Identification for piping is specified in Section 09 91 00, PAINTING.

B. Interior (Indoor) Equipment: Engraved nameplates, with letters not less than 5 mm (3/16 inch) high of brass with black-filled letters, or rigid black plastic with white letters specified in Section 09 91 00, PAINTING permanently fastened to the equipment. Identify unit components such as coils, filters, fans, etc.

C. Exterior (Outdoor) Equipment: Brass nameplates, with engraved black filled letters, not less than 5 mm (3/16 inch) high riveted or bolted to the equipment.

D. Control Items: Label all instrumentation, temperature and humidity sensors, controllers and control dampers. Identify and label each item as they appear on the control diagrams.

E. Valve Tags and Lists:

1. Boiler Plant: Provide for all valves.
2. Valve tags: Engraved black filled numbers and letters not less than 15 mm (1/2 inch) high for number designation, and not less than 6 mm (1/4 inch) for service designation on 19-gauge 40 mm (1-1/2 inches) round brass disc, attached with brass "S" hook or brass chain.
3. Valve lists: Typed or printed plastic coated card(s), sized 215 mm (8-1/2 inches) by 275 mm (11 inches) showing tag number, valve function and area of control, for each service or system. Punch sheets for a 3-ring notebook.
4. Provide detailed plan for each floor of the building indicating the location and valve number for each valve. Identify location of each valve with a color-coded thumb tack in ceiling.

2.10 FIRESTOPPING

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

2.11 GALVANIZED REPAIR COMPOUND

A. Mil-P-21035B, paint form.

2.12 HVAC PIPE AND EQUIPMENT SUPPORTS AND RESTRAINTS

A. Vibration Isolators: Refer to Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.

B. Pipe Hangers and Supports for Boiler Plant: Refer to Section 23 21 11, BOILER PLANT PIPING SYSTEMS.

C. Supports for Roof Mounted Items:

1. Equipment: Equipment rails shall be galvanized steel, minimum 1.3 mm (18 gauge), with integral baseplate, continuous welded corner seams, factory installed 50 by 100 mm (2 by 4 inches) treated wood nailer, 1.3 mm (18 gauge) galvanized steel counter flashing cap with screws, built-in cant strip, (except for gypsum or tectum deck), minimum height 275 mm (11 inches). For surface insulated roof deck, provide raised cant strip to start at the upper surface of the insulation.
2. Pipe/duct pedestals: Provide a galvanized Unistrut channel welded to U-shaped mounting brackets which are secured to side of rail with galvanized lag bolts.

D. Pipe Supports: Comply with MSS SP-58. Type Numbers specified refer to this standard. For selection and application comply with MSS SP-58. Refer to Section 05 50 00, METAL FABRICATIONS, for miscellaneous metal support materials and prime coat painting requirements.

E. Attachment to Concrete Building Construction:

1. Concrete insert: MSS SP-58, Type 18.
2. Self-drilling expansion shields and machine bolt expansion anchors: Permitted in concrete not less than 100 mm (4 inches) thick when approved by the COR for each job condition.
3. Power-driven fasteners: Permitted in existing concrete or masonry not less than 100 mm (4 inches) thick when approved by the COR for each job condition.

F. Attachment to Steel Building Construction:
   1. Welded attachment: MSS SP-58, Type 22.
   2. Beam clamps: MSS SP-58, Types 20, 21, 28 or 29. Type 23 C-clamp may be used for individual copper tubing up to 23 mm (7/8 inch) outside diameter.

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

H. Hanger Rods: Hot-rolled steel, ASTM A36/A36M or ASTM A575 for allowable load listed in MSS SP-58. For piping, provide adjustment means for controlling level or slope. Types 13 or 15 turn-buckles shall provide 40 mm (1-1/2 inches) minimum of adjustment and incorporate locknuts. All-thread rods are acceptable.

I. Hangers Supporting Multiple Pipes (Trapeze Hangers): Galvanized, cold formed, lipped steel channel horizontal member, not less than 41 by 41 mm (1-5/8 by 1-5/8 inches), 2.7 mm (12 gauge), designed to accept special spring held, hardened steel nuts. Prohibited for steam supply and condensate piping.
   1. Allowable hanger load: Manufacturers rating less 91 kg (200 pounds).
   2. Guide individual pipes on the horizontal member of every other trapeze hanger with 6 mm (1/4 inch) U-bolt fabricated from steel rod. Provide Type 40 insulation shield, secured by two 15 mm (1/2 inch) galvanized steel bands, or preinsulated calcium silicate shield for insulated piping at each hanger.

J. Supports for Piping Systems:
   1. Select hangers sized to encircle insulation on insulated piping. Refer to Section 23 07 11, HVAC AND BOILER PLANT INSULATION for insulation thickness. To protect insulation, provide Type 39 saddles for roller type supports or preinsulated calcium silicate shields. Provide Type 40 insulation shield or preinsulated calcium silicate shield at all other types of supports and hangers including those for preinsulated piping.
   2. Piping Systems except High and Medium Pressure Steam (MSS SP-58):
      a. Standard clevis hanger: Type 1; provide locknut.
      b. Riser clamps: Type 8.
      c. Wall brackets: Types 31, 32 or 33.
      d. Roller supports: Type 41, 43, 44 and 46.

e. Saddle support: Type 36, 37 or 38.

f. Turnbuckle: Types 13 or 15. Preinsulate.

g. U-bolt clamp: Type 24.

h. Copper Tube:

1) Hangers, clamps and other support material in contact with tubing shall be painted with copper colored epoxy paint, plastic coated or taped with non-adhesive isolation tape to prevent electrolysis.

2) For vertical runs use epoxy painted or plastic-coated riser clamps.

3) For supporting tube to strut: Provide epoxy painted pipe straps for copper tube or plastic inserted vibration isolation clamps.

4) Insulated Lines: Provide pre-insulated calcium silicate shields sized for copper tube.

i. Supports for plastic piping: As recommended by the pipe manufacturer with black rubber tape extending one inch beyond steel support or clamp.

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 psig) compressive strength calcium silicate shields encased in galvanized metal.

2. Pre-insulated calcium silicate shields to be installed at the point of support during erection.
3. Shield thickness 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 25 mm (1 inch) past the sheet metal. Provide for an adequate vapor barrier in chilled lines.
   b. The pre-insulated calcium silicate shield shall support the maximum allowable water filled span as indicated in MSS SP-58. To support the load, the shields may have one or more of the following features: structural inserts 4138 kPa (600 psig) compressive strength, an extra bottom metal shield, or formed structural steel (ASTM A36/A36M) wear plates welded to the bottom sheet metal jacket.
5. Shields may be used on steel clevis hanger type supports, roller supports or flat surfaces.

L. Seismic Restraint of Piping and Ductwork: Refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS. Comply with MSS SP-127.

2.13 PIPE PENETRATIONS

A. Install sleeves during construction for other than blocked out floor openings for risers in mechanical bays.

B. To prevent accidental liquid spills from passing to a lower level, provide the following:
1. For sleeves: Extend sleeve 25 mm (1 inch) above finished floor and provide sealant for watertight joint.
2. For blocked out floor openings: Provide 40 mm (1-1/2 inch) angle set in silicone adhesive around opening.
3. For drilled penetrations: Provide 40 mm (1-1/2 inch) angle ring or square set in silicone adhesive around penetration.

C. Penetrations through beams or ribs are prohibited but may be installed in concrete beam flanges. Any deviation from these requirements must receive prior approval of COR.

D. Sheet Metal, Plastic, or Moisture-resistant Fiber Sleeves: Provide for pipe passing through floors, interior walls, and partitions, unless brass or steel pipe sleeves are specifically called for below.

E. Cast Iron or Zinc Coated Pipe Sleeves: Provide for pipe passing through exterior walls below grade. Make space between sleeve and pipe watertight with a modular or link rubber seal. Seal shall be applied at both ends of sleeve.

F. Galvanized Steel or an alternate Black Iron Pipe with asphalt coating Sleeves: Provide for pipe passing through concrete beam flanges, except where brass pipe sleeves are called for. Provide sleeve for pipe passing through floor of mechanical rooms, laundry work rooms, and animal rooms above basement. Except in mechanical rooms, connect sleeve with floor plate.

G. Brass Pipe Sleeves: Provide for pipe passing through quarry tile, terrazzo or ceramic tile floors. Connect sleeve with floor plate.

H. Sleeves are not required for wall hydrants for fire department connections or in drywall construction.

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

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

2.14 PENETRATIONS

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

B. Provide firestopping for openings through fire and smoke barriers, maintaining minimum required rating of floor, ceiling or wall assembly. See section 07 84 00, FIRESTOPPING.

2.15 SPECIAL TOOLS AND LUBRICANTS

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

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

C. Refrigerant Tools: Provide system charging/Evacuation equipment, gauges, fittings, and tools required for maintenance of furnished equipment.

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

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

2.16 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. Use also where insulation ends on exposed water supply pipe drop from overhead. Provide a watertight joint in spaces where brass or steel pipe sleeves are specified.

2.17 ASBESTOS

A. Materials containing asbestos are prohibited.

PART 3 - EXECUTION

3.1 GENERAL

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

3.2 ARRANGEMENT AND INSTALLATION OF EQUIPMENT AND PIPING

A. Location of piping, sleeves, inserts, hangers, and equipment, access provisions shall be coordinated with the work of all trades. The coordination/shop drawings shall be submitted for review. Locate piping, sleeves, inserts, hangers, ductwork and equipment clear of windows, doors, openings, light outlets, and other services and utilities. Equipment coordination/shop drawings shall be prepared to coordinate proper location and personnel access of all facilities. The drawings shall be submitted for review. Follow manufacturer's published recommendations for installation methods not otherwise specified.

B. Operating Personnel Access and Observation Provisions: Select and arrange all equipment and systems to provide clear view and easy access, without use of portable ladders, for maintenance and operation of all devices including, but not limited to: all equipment items, valves, filters, strainers, transmitters, sensors, control devices. All gauges and indicators shall be clearly visible by personnel standing on the floor or on permanent platforms. Do not reduce or change maintenance and operating space and access provisions that are shown on the contract documents.

C. Boiler Control Panel Locations: Locate and orient panels so that operating personnel standing in front of boilers can view the control switches and displays on the panel face for all boilers on the aisle. Panels mounted on the sides near the front of fire tube boilers are prohibited.

D. Boiler and Economizer Access Platforms: Arrange piping and equipment to allow access by a person standing on the platforms to all valves located above the boilers, to boiler manways located on top of the boilers, and to all economizer valves and access panels.

E. Equipment and Piping Support: Coordinate structural systems necessary for pipe and equipment support with pipe and equipment locations to permit proper installation.

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

G. Cutting Holes:

1. Cut holes through concrete and masonry by rotary core drill. Pneumatic hammer, impact electric, and hand or manual hammer type

drill is prohibited, except as permitted by COR where working area space is limited.

2. Locate holes to avoid interference with structural members such as slabs, columns, ribs, beams or reinforcing. Holes shall be laid out in advance and drilling done only after approval by COR. If the Contractor considers it necessary to drill through structural members, this matter shall be referred to COR for approval.
3. Do not penetrate membrane waterproofing.

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. Electrical Interconnection of Instrumentation or Controls: This generally not shown but must be provided. This includes interconnections of sensors, transmitters, transducers, control devices, control and instrumentation panels, instruments and computer workstations. Devices shall be located so they are easily accessible for testing, maintenance, calibration, etc. The COR has the final determination on what is accessible and what is not. Comply with NFPA 70.

J. 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.

K. Concrete and Grout: Use concrete and non-shrink grout 21 MPa (3000 psig) minimum, specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.

L. Install gauges, thermometers, valves and other devices with due regard for ease in reading or operating and maintaining said devices. Locate and position thermometers and gauges to be easily read by operator or staff standing on floor or walkway provided. Servicing shall not require dismantling adjacent equipment or pipe work.

M. Install steam piping expansion joints as per manufacturer’s recommendations.

N. Work in Existing Building:

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

O. Switchgear/Electrical Equipment Drip Protection: Every effort shall be made to eliminate the installation of pipe above electrical and data/telephone switchgear. If this is not possible, encase pipe in a second pipe with a minimum of joints. Installation of piping, ductwork, leak protection apparatus or other installations foreign to the electrical installation shall not be located in the space equal to the width and depth of the equipment and extending from to a height of 1.8 m (6 feet) above the equipment or to ceiling structure, whichever is lower (NFPA 70).

P. Inaccessible Equipment:

1. Where the Government determines that the Contractor has installed equipment not conveniently accessible for operation and maintenance or inspections, equipment shall be removed, and reinstalled or remedial action performed as directed at no additional cost or time to the Government.
2. The term "conveniently accessible" is defined as capable of being reached without the use of ladders, or without climbing or crawling under or over obstacles such as, but not limited to motors, fans, pumps, belt guards, transformers, high voltage lines, conduit and raceways, piping, hot surfaces, and ductwork. The COR has final determination on whether an installation meets this requirement or not.

3.3 TEMPORARY PIPING AND EQUIPMENT

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

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

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

3.4 RIGGING

A. Design is based on application of available equipment. Openings in building structures are planned to accommodate design scheme.

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

C. Close all openings in the building when not required for rigging operations to maintain proper environment in the facility for Government operation and maintenance of service.

D. Contractor shall provide all facilities required to deliver specified equipment and place on foundations. Attachments to structures for rigging purposes and support of equipment on structures shall be Contractor's full responsibility. Upon request, the Government will check structure adequacy and advise Contractor of recommended restrictions.

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

F. Follow approved rigging plan.

G. Restore building to original condition upon completion of rigging work.

3.5 PIPE AND EQUIPMENT SUPPORTS

A. Where hanger spacing does not correspond with joist or rib spacing, use structural steel channels designed by a structural engineer, secured directly to joist and rib structure that will correspond to the required hanger spacing, and then suspend the equipment and piping from the channels. Drill or burn holes in structural steel only with the prior approval of the COR.

B. Use of chain pipe supports; wire or strap hangers; wood for blocking, stays and bracing; or hangers suspended from piping above are prohibited. Replace or thoroughly clean rusty products and paint with zinc primer.

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

D. HVAC Horizontal Pipe Support Spacing: Refer to MSS SP-58. Provide additional supports at valves, strainers, in-line pumps and other heavy components. Provide a support within one foot of each elbow.

E. HVAC Vertical Pipe Supports:

1. Up to 150 mm (6 inch) pipe, 9 m (30 feet) long, bolt riser clamps to the pipe below couplings, or welded to the pipe and rests supports securely on the building structure.
2. Vertical pipe larger than the foregoing, support on base elbows or tees, or substantial pipe legs extending to the building structure.

F. Overhead Supports:

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

G. Floor Supports:

1. Provide concrete bases, concrete anchor blocks and pedestals, and structural steel systems for support of equipment and piping. Concrete bases and structural systems shall be anchored and doweled

to resist forces under operating and seismic conditions (if applicable) without excessive displacement or structural failure.

2. Bases and supports shall not be located and installed until equipment mounted thereon has been approved. Bases shall be sized to match equipment mounted thereon plus 50 mm (2 inch) excess on all edges. Boiler foundations shall have horizontal dimensions that exceed boiler base frame dimensions by at least 150 mm (6 inches) on all sides. Structural contract documents shall be reviewed for additional requirements. Bases shall be neatly finished and smoothed, shall have chamfered edges at the top, and shall be suitable for painting.
3. All equipment shall be shimmed, leveled, firmly anchored, and grouted with epoxy grout. Anchor bolts shall be placed in sleeves, anchored to the bases. Fill the annular space between sleeves and bolts with a granular material to permit alignment and realignment.
4. For seismic anchoring, refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

3.6 MECHANICAL DEMOLITION

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

B. In an operating facility, maintain the operation, cleanliness and safety. Government personnel will be carrying on their normal duties of operating, cleaning and maintaining equipment and plant operation. Confine the work to the immediate area concerned; maintain cleanliness and wet down demolished materials to eliminate dust. Debris accumulated in the area to the detriment of plant operation is prohibited. Perform all flame cutting to maintain the fire safety integrity of this plant. Adequate fire extinguishing facilities shall be available at all times. Perform all work in accordance with recognized fire protection standards. Inspection will be made by personnel of the VAMC, and

Contractor shall follow all directives of the COR with regard to rigging, safety, fire safety, and maintenance of operations.

C. Unless specified otherwise, all piping, wiring, conduit, and other devices associated with the equipment not re-used in the new work shall be completely removed from Government property per Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT. This includes all concrete 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 contract documents where specifically covered. Structural integrity of the building system shall be maintained. Reference shall also be made to the contract documents of the other disciplines in the project for additional facilities to be demolished or handled.

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

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.

B. In addition, the following special conditions apply:

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

2. The following material and equipment shall not be painted:
   a. Motors, controllers, control switches, and safety switches.
   b. Control and interlock devices.
   c. Regulators.
   d. Pressure reducing valves.
   e. Control valves and thermostatic elements.
   f. Lubrication devices and grease fittings.
   g. Copper, brass, aluminum, stainless steel and bronze surfaces.
   h. Valve stems and rotating shafts.
   i. Pressure gauges and thermometers.
   j. Glass.
   k. Nameplates.
3. Control and instrument panels shall be cleaned, damaged surfaces repaired, and shall be touched-up with matching paint obtained from panel manufacturer.
4. Pumps, 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. Boilers, Burners, Fuel Trains and Accessories: Retain manufacturer's factory finish. Touch up or recoat as necessary to provide smooth, even-colored and even-textured finish.
6. Temporary Facilities: Apply paint to surfaces that do not have existing finish coats. This may include painting exposed metals where hangers were removed or where equipment was moved or removed.
7. Paint shall withstand the following temperatures without peeling or discoloration:
   a. Boiler Stack and Breeching: 65 degrees C (150 degrees F) on insulation jacket surface and 315 degrees C (600 degrees F) on metal surface of stacks and breeching.
   b. Condensate and Feedwater 38 degrees C (100 degrees F) on insulation jacket surface and 121 degrees C (250 degrees F) on metal pipe surface.
   c. Steam: 52 degrees C (125 degrees F) on insulation jacket surface and 190 degrees C (374 degrees F) on metal pipe surface.

8. 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.
9. Lead based paints are prohibited.

3.8 IDENTIFICATION SIGNS

A. Provide laminated plastic signs, with engraved lettering not less than 5 mm (3/16 inch) high, designating functions, for all equipment, switches, motor controllers, relays, meters, control devices, including automatic control valves. Nomenclature and identification symbols shall correspond to that used in maintenance manual, and in diagrams specified elsewhere. Attach by chain, adhesive, or screws.

B. Factory Built Equipment: Metal plate, securely attached, with name and address of manufacturer, serial number, model number, size, performance.

C. Boiler Plant Instrumentation Panel: Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.

D. Boiler Control Panels: Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT

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

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 per coupling manufacturer’s tolerances when both motor and driven machine are operating at normal temperatures.

3.10 LUBRICATION

A. All equipment and devices requiring lubrication shall be lubricated prior to initial operation. Field-check all devices for proper lubrication.

B. All devices and equipment shall be equipped with required lubrication fittings or devices. A minimum of 0.95 liter (1 quart) of oil and 0.45 kg (1 pound) of grease of manufacturer's recommended grade and type for each different application shall be provided; also provide 12 grease sticks for lubricated plug valves. All materials shall be delivered to COR in unopened containers that are properly identified as to application.

C. All lubrication points shall be accessible without disassembling equipment, except to remove access plates.

D. All lubrication points shall be extended to one side of the equipment.

3.11 STARTUP, TEMPORARY OPERATION AND TESTING

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

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

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

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

3.12 OPERATING AND PERFORMANCE TESTS

A. Prior to the final inspection, perform required tests as specified in Section 01 00 00, GENERAL REQUIREMENTS, paragraph, TESTS; Section 23 08 11, DEMONSTRATIONS AND TESTS FOR BOILER PLANT; and in individual Division 23 specification sections and submit the test reports and records to the COR.

B. Should evidence of malfunction in any tested system, or piece of equipment or component part thereof, occur during or as a result of tests, make proper corrections, repairs or replacements, and repeat tests at no additional cost or time to the Government.

C. When completion of certain work or system occurs at a time when final control settings and adjustments cannot be properly made to make performance tests, then conduct such performance tests and finalize control settings for heating systems and for cooling systems respectively during first actual seasonal use of respective systems following completion of work. Rescheduling of these tests shall be requested in writing to COR for approval.

D. No adjustments maybe made during the acceptance inspection. All adjustments shall have been made by this point.

E. Perform tests as required for commissioning provisions in accordance with Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS and Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

3.13 DEMONSTRATIONS AND TESTS, TEMPORARY BOILER PLANT EQUIPMENT

A. Test prior to placing in service.

B. Demonstrate to COR the proper operation of all equipment, instruments, operating and safety controls, and devices.

C. Demonstrate to COR the proper operation of burners.

1. Emissions within limits specified for new boilers on this project.
2. Stable flame at all operating points with no pulsations.
3. No flame impingement on the Morrison tube or furnace walls, or water tubes.
4. Smooth flame light off, with no delays, puffs or flashbacks.
5. Turndown capability as specified.

D. Develop full steam output capacity required.

E. New boilers installed in temporary location:

1. Perform all tests required by boiler specification.
2. Perform complete retest after boiler is placed in its permanent location.

3.14 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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

3.15 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer’s technical representative for 4 hours to instruct each VA personnel responsible in operation and maintenance of the system.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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02-01-20

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

C. Abbreviations/Acronyms:

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

26. CPD: Condensate Pump Discharge
27. CPM: Cycles Per Minute
28. CPVC: Chlorinated Polyvinyl Chloride
29. CRS: Corrosion Resistant Steel
30. CTPD: Condensate Transfer Pump Discharge
31. CTPS: Condensate Transfer Pump Suction
32. CW: Cold Water
33. CWP: Cold Working Pressure
34. CxA: Commissioning Agent
35. dB: Decibels
36. dB(A): Decibels (A weighted)
37. DDC: Direct Digital Control
38. DI: Digital Input
39. DO: Digital Output
40. DVD: Digital Video Disc
41. DN: Diameter Nominal
42. DWV: Drainage, Waste and Vent
43. EPDM: Ethylene Propylene Diene Monomer
44. EPT: Ethylene Propylene Terpolymer
45. ETO: Ethylene Oxide
46. F: Fahrenheit
47. FAR: Federal Acquisition Regulations
48. FD: Floor Drain
49. FED: Federal
50. FG: Fiberglass
51. FGR: Flue Gas Recirculation
52. FOS: Fuel Oil Supply
53. FOR: Fuel Oil Return
54. FSK: Foil-Scrim-Kraft facing
55. FWPD: Feedwater Pump Discharge
56. FWPS: Feedwater Pump Suction
57. GC: Chilled Glycol Water Supply
58. GCR: Chilled Glycol Water Return
59. GH: Hot Glycol Water Heating Supply
60. GHR: Hot Glycol Water Heating Return
61. gpm: Gallons Per Minute

62. HDPE: High Density Polyethylene
63. Hg: Mercury
64. HOA: Hands-Off-Automatic
65. hp: Horsepower
66. HPS: High Pressure Steam (414 kPa (60 psig) and above)
67. HPR: High Pressure Steam Condensate Return
68. HW: Hot Water
69. HWH: Hot Water Heating Supply
70. HWHR: Hot Water Heating Return
71. Hz: Hertz
72. ID: Inside Diameter
73. IPS: Iron Pipe Size
74. kg: Kilogram
75. klb: 1000 lb
76. kPa: Kilopascal
77. lb: Pound
78. lb/hr: Pounds Per Hour
79. L/s: Liters Per Second
80. L/min: Liters Per Minute
81. LPS: Low Pressure Steam (103 kPa (15 psig) and below)
82. LPR: Low Pressure Steam Condensate Gravity Return
83. MAWP: Maximum Allowable Working Pressure
84. MAX: Maximum
85. MBtu/h: 1000 Btu/h
86. MBtu: 1000 Btu
87. MED: Medical
88. m: Meter
89. MFG: Manufacturer
90. mg: Milligram
91. mg/L: Milligrams Per Liter
92. MIN: Minimum
93. MJ: Megajoules
94. ml: Milliliter
95. mm: Millimeter
96. MPS: Medium Pressure Steam (110 kPa (16 psig) through 414 kPa (60 psig))

97. MPR: Medium Pressure Steam Condensate Return
98. MW: Megawatt
99. NC: Normally Closed
100. NF: Oil Free Dry (Nitrogen)
101. Nm: Newton Meter
102. NO: Normally Open
103. NOx: Nitrous Oxide
104. NPT: National Pipe Thread
105. NPS: Nominal Pipe Size
106. OD: Outside Diameter
107. OSD: Open Sight Drain
108. OS&Y: Outside Stem and Yoke
109. PC: Pumped Condensate
110. PID: Proportional-Integral-Differential
111. PLC: Programmable Logic Controllers
112. PP: Polypropylene
113. PPE: Personal Protection Equipment
114. ppb: Parts Per Billion
115. ppm: Parts Per Million
116. PRV: Pressure Reducing Valve \
117. PSIA: Pounds Per Square Inch Absolute
118. psig: Pounds Per Square Inch Gauge
119. PTFE: Polytetrafluoroethylene
120. PVC: Polyvinyl Chloride
121. PVDC: Polyvinylidene Chloride Vapor Retarder Jacketing, White
122. PVDF: Polyvinylidene Fluoride
123. rad: Radians
124. RH: Relative Humidity
125. RO: Reverse Osmosis
126. rms: Root Mean Square
127. RPM: Revolutions Per Minute
128. RS: Refrigerant Suction
129. RTD: Resistance Temperature Detectors
130. RTRF: Reinforced Thermosetting Resin Fittings
131. RTRP: Reinforced Thermosetting Resin Pipe
132. SCFM: Standard Cubic Feet Per Minute

133. SPEC: Specification
134. SPS: Sterile Processing Services
135. STD: Standard
136. SDR: Standard Dimension Ratio
137. SUS: Saybolt Universal Second
138. SW: Soft water
139. SWP: Steam Working Pressure
140. TAB: Testing, Adjusting, and Balancing
141. TDH: Total Dynamic Head
142. TEFC: Totally Enclosed Fan-Cooled
143. TFE: Tetrafluoroethylene
144. THERM: 100,000 Btu
145. THHN: Thermoplastic High-Heat Resistant Nylon Coated Wire
146. THWN: Thermoplastic Heat & Water-Resistant Nylon Coated Wire
147. T/P: Temperature and Pressure
148. USDA: U.S. Department of Agriculture
149. V: Volt
150. VAC: Vacuum
151. VA: Veterans Administration
152. VAC: Voltage in Alternating Current
153. VA CFM: VA Construction & Facilities Management
154. VA CFM CSS: VA Construction & Facilities Management, Consulting Support Service
155. VAMC: Veterans Administration Medical Center
156. VHA OCAMES: Veterans Health Administration – Office of Capital Asset Management Engineering and Support
157. VR: Vacuum condensate return
158. WCB: Wrought Carbon Steel, Grade B
159. WG: Water Gauge or Water Column
160. 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 91 00, GENERAL COMMISSIONING REQUIREMENTS.
E. Section 02 82 11, TRADITIONAL ASBESTOS ABATEMENT.

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

G. Section 05 31 00, STEEL DECKING.

H. Section 05 36 00, COMPOSITE METAL DECKING.

I. Section 05 50 00, METAL FABRICATIONS.

J. Section 07 84 00, FIRESTOPPING.

K. Section 07 92 00, JOINT SEALANTS.

L. Section 09 91 00, PAINTING.

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

N. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION.

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

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

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

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

S. Section 23 09 11, DEMONSTRATIONS AND TESTS FOR BOILER PLANT

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

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

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

W. 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. Where conflicts occur these specifications and the VHA standard will govern.

B. Air Movement and Control Association (AMCA):

410-1996................Recommended Safety Practices for Users and Installers of Industrial and Commercial Fans

C. American Society of Mechanical Engineers (ASME):

B31.1-2018..............Power Piping

B31.9-2014..............Building Services Piping

ASME Boiler and Pressure Vessel Code:

BPVC Section IX-2019 Welding, Brazing, and Fusing Qualifications

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

A36/A36M-2014..........Standard Specification for Carbon Structural Steel

A575-1996(R2018)........Standard Specification for Steel Bars, Carbon, Merchant Quality, M-Grades

E. Association for Rubber Products Manufacturers (ARPM):

IP-20-2015..............Specifications for Drives Using Classical V-Belts and Sheaves

IP-21-2016..............Specifications for Drives Using Double-V (Hexagonal) Belts

IP-24-2016..............Specifications for Drives Using Synchronous Belts

IP-27-2015..............Specifications for Drives Using Curvilinear Toothed Synchronous Belts

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

SP-58-2018..............Pipe Hangers and Supports-Materials, Design, Manufacture, Selection, Application, and Installation

SP-127-2014a............Bracing for Piping Systems: Seismic–Wind–Dynamic Design, Selection, and Application

G. Military Specifications (MIL):

MIL-P-21035B-2013.......Paint High Zinc Dust Content, Galvanizing Repair (Metric)

H. National Fire Protection Association (NFPA):

70-2017.................National Electrical Code (NEC)

101-2018................Life Safety Code

I. Department of Veterans Affairs (VA):

PG-18-10-2016...........Physical Security and Resiliency Design Manual

1.4 SUBMITTALS

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

B. Information and material submitted under this section shall be marked “SUBMITTED UNDER SECTION 23 05 11, COMMON WORK RESULTS FOR HVAC”, with applicable paragraph identification.

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

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

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

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

G. Submittals and shop drawings for interdependent items, containing applicable descriptive information, shall be furnished together. Coordinate and properly integrate materials and equipment to provide a completely compatible and efficient installation.

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

I. Manufacturer's Literature and Data: Include full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity. Submit under the pertinent section rather than under this section.
   1. Submit belt drive with the driven equipment. Submit selection data for specific drives when requested by the COR.
   2. Submit electric motor data and variable speed drive data with the driven equipment.
   3. Equipment and materials identification.
   4. Fire-stopping materials.

5. Hangers, inserts, supports and bracing. Provide complete stress analysis for variable spring and constant support hangers.
6. Wall, floor, and ceiling plates.

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

K. HVAC Maintenance Data and Operating Instructions:

1. Maintenance and operating manuals in accordance with Section 01 00 00, GENERAL REQUIREMENTS, Article, INSTRUCTIONS, for systems and equipment.
2. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replacement parts, and troubleshooting guide:

a. Include complete list indicating all components of the systems.
b. Include complete diagrams of the internal wiring for each item of equipment.
c. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

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

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

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

N. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

1.5 QUALITY ASSURANCE

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

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

C. Equipment Vibration Tolerance:

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

D. Products Criteria:

1. Standard Products: Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products for at least 3 years (or longer as specified elsewhere). The design, model and size of each item shall have been in satisfactory and efficient operation on at least three installations for approximately three years. However, digital electronics devices, software and systems such as controls, instruments, computer work station, shall be the current generation of technology and basic design that has a proven satisfactory service record of at least three years. See other specification sections for any exceptions and/or additional requirements.
2. Refer to all other sections for quality assurance requirements for systems and equipment specified therein.
3. All items furnished shall be free from defects that would adversely affect the performance, maintainability and appearance of individual components and overall assembly.
4. The products and execution of work specified in Division 33 shall conform to the referenced codes and standards as required by the specifications. Local codes and amendments shall be enforced, along with requirements of local utility companies. The most stringent requirements of these specifications, local codes, or utility

company requirements shall always apply. Any conflicts shall be brought to the attention of the COR.

5. Multiple Units: When two or more units of materials or equipment of the same type or class are required, these units shall be of the same manufacturer and model number, or if different models are required they shall be of the same manufacturer and identical to the greatest extent possible (i.e., same model series).
6. Assembled Units: Performance and warranty of all components that make up an assembled unit shall be the responsibility of the manufacturer of the completed assembly.
7. Nameplates: Nameplate bearing manufacturer's name or identifiable trademark shall be securely affixed in a conspicuous place on equipment, or name or trademark cast integrally with equipment, stamped or otherwise permanently marked on each item of equipment.
8. Use of asbestos products or equipment or materials containing asbestos is prohibited.

E. HVAC Equipment Service Providers: Service providers shall be authorized and trained by the manufacturers of the equipment supplied. These providers shall be capable of responding onsite and provide acceptable service to restore equipment operations within 4 hours of receipt of notification by phone, e-mail or fax in event of an emergency, such as the shutdown of equipment; or within 24 hours in a non-emergency. Submit names, mail and e-mail addresses and phone numbers of service personnel and companies providing service under these conditions for (as applicable to the project): fans, air handling units, chillers, cooling towers, control systems, pumps, critical instrumentation, computer workstation and programming.

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

1. Qualify welding processes and operators for piping according to ASME BPVC Section IX. Provide proof of current certification.
2. Comply with provisions of ASME B31 series "Code for Pressure Piping".

3. Certify that each welder and welding operator has passed American Welding Society (AWS) qualification tests for the welding processes involved, and that certification is current.
4. All welds shall be stamped according to the provisions of the AWS or ASME as required herein and by the associated code.

G. Manufacturer's Recommendations: Where installation procedures or any part thereof are required to be in accordance with the recommendations of the manufacturer of the material being installed, printed copies of these recommendations shall be furnished to the COR with submittals. Installation of the item will not be allowed to proceed until the recommendations are received. Failure to furnish these recommendations can be cause for rejection of the material and removal by the Contractor and no additional cost or time to the Government.

H. Execution (Installation, Construction) Quality:
1. Apply and install all items in accordance with manufacturer's written instructions. Refer conflicts between the manufacturer's instructions and the contract documents to the COR for resolution. Provide written hard copies and computer files on CD or DVD of manufacturer’s installation instructions to the COR with submittals prior to commencing installation of any item. Installation of the item will not be allowed to proceed until the recommendations are received and approved by the VA. Failure to furnish these recommendations is a cause for rejection of the material.
2. All items that require access, such as for operating, cleaning, servicing, maintenance, and calibration, shall be easily and safely accessible by persons standing at floor level, or standing on permanent platforms, without the use of portable ladders. Examples of these items include, but are not limited to, all types of valves, filters and strainers, transmitters, control devices. Prior to commencing installation work, refer conflicts between this requirement and contract documents to the COR for resolution. Failure of the Contractor to resolve, or point out any issues will result in the Contractor correcting at no additional cost or time to the Government.
3. Complete coordination/shop drawings shall be required in accordance with Article, SUBMITTALS. Construction work shall not start on any

system until the coordination/shop drawings have been approved by VA.

4. Workmanship/craftsmanship will be of the highest quality and standards. The VA reserves the right to reject any work based on poor quality of workmanship this work shall be removed and done again at no additional cost or time to the Government.

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

J. Guaranty: Warranty of Construction, FAR Clause 52.246-21.

1.6 DELIVERY, STORAGE AND HANDLING

A. Protection of Equipment:

1. Equipment and material placed on the job site shall remain in the custody of the Contractor until phased acceptance, whether or not the Government has reimbursed the Contractor for the equipment and material. The Contractor is solely responsible for the protection of such equipment and material against any damage or theft.
2. Large equipment such as boilers, chillers, cooling towers, fans, and air handling units if shipped on open trailer trucks shall be covered with shrink on plastics or water proof tarpaulins that provide protection from exposure to rain, road salts and other transit hazards. Protection shall be kept in place until equipment is moved into a building or installed as designed.
3. Repair damaged equipment in first class, new operating condition and appearance; or, replace same as determined and directed by the COR. Such repair or replacement shall be at no additional cost or time to the Government.
4. Protect interiors of new equipment and piping systems against entry of foreign matter. Clean both inside and outside before painting or placing equipment in operation.
5. Existing equipment and piping being worked on by the Contractor shall be under the custody and responsibility of the Contractor and shall be protected as required for new work.
6. Protect plastic piping and tanks from ultraviolet light (sunlight).

B. Cleanliness of Piping and Equipment Systems:
   1. Exercise care in storage and handling of equipment and piping material to be incorporated in the work. Remove debris arising from cutting, threading and welding of piping.
   2. Piping systems shall be flushed, blown or pigged as necessary to deliver clean systems.
   3. Clean interior of all tanks prior to delivery for beneficial use by the Government.
   4. Boilers shall be left clean following final internal inspection by Government insurance representative or inspector.
   5. Contractor shall be fully responsible for all costs, damage, and delay arising from failure to provide clean systems.

1.7 AS-BUILT DOCUMENTATION

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

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

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

1. As-built drawings are to be provided, with a copy of them on AutoCAD version provided on CD or DVD. The CAD drawings shall use multiple line layers with a separate individual layer for each system.

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

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

1.8 JOB CONDITIONS – WORK IN EXISTING BUILDING

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

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

C. Steam and Condensate Service Interruptions: Limited steam and condensate service interruptions, as required for interconnections of new and existing systems, will be permitted by the COR during periods when the demands are not critical to the operation of the VAMC. These non-critical periods are limited to between 8 pm and 5 am in the appropriate off-season (if applicable). Provide at least 10 working days advance notice to the COR. The request shall include a detailed plan on the proposed shutdown and the intended work to be done along with manpower levels. All equipment and materials must be onsite and verified with plan 5 days prior to the shutdown or it will need to be rescheduled.

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

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

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

G. Temporary Facilities: Refer to Article, TEMPORARY PIPING AND EQUIPMENT in this section.

PART 2 - PRODUCTS

2.1 FACTORY-ASSEMBLED PRODUCTS

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

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

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

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

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

D. Major items of equipment, which serve the same function, must be the same make and model. Exceptions must be approved by the VA, but may be permitted if performance requirements cannot be met.

2.2 COMPATIBILITY OF RELATED EQUIPMENT

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

2.3 V-BELT DRIVES

A. Type: ARPM standard V-belts with proper motor pulley and driven sheave. Belts shall be constructed of reinforced cord and rubber.

B. Dimensions, rating and selection standards: ARPM IP-20 and ARPM IP-21.

C. Minimum Horsepower Rating: Motor horsepower plus recommended ARPM service factor (not less than 20 percent) in addition to the ARPM allowances for pitch diameter, center distance, and arc of contact.

D. Maximum Speed: 25 m/s (5000 feet per minute).

E. Adjustment Provisions: For alignment and ARPM standard allowances for installation and take-up.

F. Drives may utilize a single V-Belt (any cross section) when it is the manufacturer's standard.

G. Multiple Belts: Matched to ARPM specified limits by measurement on a belt measuring fixture. Seal matched sets together to prevent mixing or partial loss of sets. Replacement, when necessary, shall be an entire set of new matched belts.

H. Sheaves and Pulleys:
   1. Material: Pressed steel, or close-grained cast iron.
   2. Bore: Fixed or bushing type for securing to shaft with keys.
   3. Balanced: Statically and dynamically.
   4. Groove spacing for driving and driven pulleys shall be the same.
I. Drive Types, Based on ARI 435:
   1. Provide adjustable-pitch drive as follows:
      a. Fan speeds up to 1800 RPM: 7.5 kW (10 horsepower) and smaller.
      b. Fan speeds over 1800 RPM: 2.2 kW (3 horsepower) and smaller.
   2. Provide fixed-pitch drives for drives larger than those listed above.
   3. The final fan speeds required to just meet the system CFM and pressure requirements, without throttling the design air flow branch, shall be determined by adjustment of a temporary adjustable-pitch motor sheave or by fan law calculation if a fixed-pitch drive is used initially.
J. Final Drive Set: If adjustment is required beyond the capabilities of the factory drive set, the final drive set shall be provided as part of this contract at no additional cost or time to the Government.

2.4 SYNCHRONOUS BELT DRIVES

A. Type: ARPM synchronous belts with proper motor pulley and driven sheave. Belts shall be constructed of reinforced cord and rubber.
B. Dimensions, rating and selection standards: ARPM IP-24 and ARPM IP-27.
C. Minimum Horsepower Rating: Motor horsepower plus recommended ARPM service factor (not less than 20 percent) in addition to the ARPM allowances for pitch diameter, center distance, and arc of contact.
D. Maximum Speed: 25 m/s (5000 feet per minute).
E. Adjustment Provisions: For alignment and ARPM standard allowances for installation and take-up.
F. Drives may utilize a single belt of manufacturer’s standard width for the application.
G. Multiple Belts: Matched to ARPM specified limits by measurement on a belt measuring fixture. Seal matched sets together to prevent mixing or partial loss of sets. Replacement, when necessary, shall be an entire set of new matched belts.

H. Sheaves and Pulleys:

1. Material: Pressed steel, or close-grained cast iron.
2. Bore: Fixed or bushing type for securing to shaft with keys.
3. Balanced: Statically and dynamically.

I. Final Drive Set: The final fan speeds required to just meet the system CFM and pressure requirements, without throttling the design air flow branch, shall be determined by fan law calculation. If adjustment is required beyond the capabilities of the factory drive set, the final drive set shall be provided as part of this contract at no additional cost or time to the Government.

2.5 DRIVE GUARDS

A. For machinery and equipment, provide guards as shown in AMCA 410 for belts, chains, couplings, 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-gauge sheet steel; all edges shall be hemmed, and ends shall be bent into flanges and the flanges shall be 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-gauge sheet steel and expanded or perforated metal to permit observation of belts. 25 mm (1 inch) diameter hole shall be provided at each shaft centerline to permit speed measurement.

D. Materials: Sheet steel, 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 (1 inch) diameter hole at each shaft center.

2.6 LIFTING ATTACHMENTS

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

2.7 ELECTRIC MOTORS

A. All material and equipment furnished, and installation methods shall conform to the requirements of Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT; Section 26 29 11, MOTOR CONTROLLERS; and, Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES. Provide all electrical wiring, conduit, and devices necessary for the proper connection, protection and operation of the systems. Provide special energy efficient premium efficiency type motors as scheduled.

2.8 VARIABLE SPEED MOTOR CONTROLLERS

A. Refer to Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS and Section 26 29 11, MOTOR CONTROLLERS for specifications.

B. Coordinate variable speed motor controller communication protocol with Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

C. Provide variable speed motor controllers with or without a bypass contactor as indicated in contract drawings.

D. 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.

E. 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.

F. 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.

2.9 EQUIPMENT AND MATERIALS IDENTIFICATION

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

B. Interior (Indoor) Equipment: Engraved nameplates, with letters not less than 5 mm (3/16 inch) high of brass with black-filled letters, or rigid black plastic with white letters specified in Section 09 91 00, PAINTING permanently fastened to the equipment. Identify unit components such as coils, filters, fans, etc.

C. Exterior (Outdoor) Equipment: Brass nameplates, with engraved black filled letters, not less than 5 mm (3/16 inch) high riveted or bolted to the equipment.

D. Control Items: Label all instrumentation, temperature and humidity sensors, controllers and control dampers. Identify and label each item as they appear on the control diagrams.

E. Valve Tags and Lists:

1. HVAC and Mechanical Rooms: Provide for all valves other than for equipment in Section 23 82 00, CONVECTION HEATING AND COOLING UNITS and Section 23 36 00, AIR TERMNAL UNITS.
2. Valve tags: Engraved black filled numbers and letters not less than 15 mm (1/2 inch) high for number designation, and not less than 6 mm (1/4 inch) for service designation on 19-gauge 40 mm (1-1/2 inches) round brass disc, attached with brass "S" hook or brass chain.
3. Valve lists: Typed or printed plastic coated card(s), sized 215 mm (8-1/2 inches) by 275 mm (11 inches) showing tag number, valve function and area of control, for each service or system. Punch sheets for a 3-ring notebook.
4. Provide detailed plan for each floor of the building indicating the location and valve number for each valve. Identify location of each valve with a color-coded thumb tack in ceiling.

F. Ceiling Grid Labels:

1. 50 mm (2 inch) long by 15 mm (1/2 inch) wide by 0.025 mm (1 mil) thick UV resistant metalized polyester label with red border color and black custom lettering on white background interior. Peel and stick adhesive backing. Label and adhesive manufactured specifically for use in equipment inventory tagging.

2. Custom print labels with above ceiling HVAC equipment numbers.

2.10 FIRESTOPPING

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

2.11 GALVANIZED REPAIR COMPOUND

A. Mil-P-21035B, paint form.

2.12 HVAC PIPE AND EQUIPMENT SUPPORTS AND RESTRAINTS

A. Vibration Isolators: Refer to Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.

B. Supports for Roof Mounted Items:

1. Equipment: Equipment rails shall be galvanized steel, minimum 1.3 mm (18 gauge), with integral baseplate, continuous welded corner seams, factory installed 50 by 100 mm (2 by 4 inches) treated wood nailer, 1.3 mm (18 gauge) galvanized steel counter flashing cap with screws, built-in cant strip, (except for gypsum or tectum deck), minimum height 275 mm (11 inches). For surface insulated roof deck, provide raised cant strip to start at the upper surface of the insulation.
2. Pipe/duct pedestals: Provide a galvanized Unistrut channel welded to U-shaped mounting brackets which are secured to side of rail with galvanized lag bolts.

C. Pipe Supports: Comply with MSS SP-58. Type Numbers specified refer to this standard. For selection and application comply with MSS SP-58. Refer to Section 05 50 00, METAL FABRICATIONS, for miscellaneous metal support materials and prime coat painting requirements.

D. Attachment to Concrete Building Construction:

1. Concrete insert: MSS SP-58, Type 18.
2. Self-drilling expansion shields and machine bolt expansion anchors: Permitted in concrete not less than 100 mm (4 inches) thick when approved by the COR for each job condition.
3. Power-driven fasteners: Permitted in existing concrete or masonry not less than 100 mm (4 inches) thick when approved by the COR for each job condition.

E. Attachment to Steel Building Construction:

1. Welded attachment: MSS SP-58, Type 22.

2. Beam clamps: MSS SP-58, Types 20, 21, 28 or 29. Type 23 C-clamp may be used for individual copper tubing up to 23 mm (7/8 inch) outside diameter.
3. Attachment to Metal Pan or Deck: As required for materials specified in Section 05 31 00, STEEL DECKING

F. Attachment to existing structure: Support from existing floor/roof frame.

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

H. Hanger Rods: Hot-rolled steel, ASTM A36/A36M or ASTM A575 for allowable load listed in MSS SP-58. For piping, provide adjustment means for controlling level or slope. Types 13 or 15 turn-buckles shall provide 40 mm (1-1/2 inches) minimum of adjustment and incorporate locknuts. All-thread rods are acceptable.

I. Hangers Supporting Multiple Pipes (Trapeze Hangers): Galvanized, cold formed, lipped steel channel horizontal member, not less than 41 mm by 41 mm (1-5/8 inches by 1-5/8 inches), 2.7 mm (12 gauge), designed to accept special spring held, hardened steel nuts. Trapeze hangers are prohibited for use for steam supply and condensate piping.
1. Allowable hanger load: Manufacturers rating less 91 kg (200 pounds).
2. Guide individual pipes on the horizontal member of every other trapeze hanger with 6 mm (1/4 inch) U-bolt fabricated from steel rod. Provide Type 40 insulation shield, secured by two 15 mm (1/2 inch) galvanized steel bands, or preinsulated calcium silicate shield for insulated piping at each hanger.

J. Supports for Piping Systems:
1. Select hangers sized to encircle insulation on insulated piping. Refer to Section 23 07 11, HVAC AND BOILER PLANT INSULATION for insulation thickness. To protect insulation, provide Type 39 saddles for roller type supports or preinsulated calcium silicate shields. Provide Type 40 insulation shield or preinsulated calcium silicate shield at all other types of supports and hangers including those for preinsulated piping.
2. Piping Systems except High and Medium Pressure Steam (MSS SP-58):
   a. Standard clevis hanger: Type 1; provide locknut.
   b. Riser clamps: Type 8.
   c. Wall brackets: Types 31, 32 or 33.

d. Roller supports: Type 41, 43, 44 and 46.

e. Saddle support: Type 36, 37 or 38.

f. Turnbuckle: Types 13 or 15. Preinsulate.

g. U-bolt clamp: Type 24.

h. Copper Tube:

1) Hangers, clamps and other support material in contact with tubing shall be painted with copper colored epoxy paint, plastic coated or taped with non-adhesive isolation tape to prevent electrolysis.

2) For vertical runs use epoxy painted or plastic-coated riser clamps.

3) For supporting tube to strut: Provide epoxy painted pipe straps for copper tube or plastic inserted vibration isolation clamps.

4) Insulated Lines: Provide pre-insulated calcium silicate shields sized for copper tube.

i. Supports for plastic piping: As recommended by the pipe manufacturer with black rubber tape extending one inch beyond steel support or clamp.

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 psig) compressive strength calcium silicate shields encased in galvanized metal.
   2. Pre-insulated calcium silicate shields to be installed at the point of support during erection.
   3. Shield thickness 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 25 mm (1 inch) past the sheet metal. Provide for an adequate vapor barrier in chilled lines.
      b. The pre-insulated calcium silicate shield shall support the maximum allowable water filled span as indicated in MSS SP-58. To support the load, the shields may have one or more of the following features: structural inserts 4138 kPa (600 psig) compressive strength, an extra bottom metal shield, or formed structural steel (ASTM A36/A36M) wear plates welded to the bottom sheet metal jacket.
   5. Shields may be used on steel clevis hanger type supports, roller supports or flat surfaces.

L. Seismic Restraint of Piping and Ductwork: Refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS. Comply with MSS SP-127.

2.13 PIPE PENETRATIONS

A. Install sleeves during construction for other than blocked out floor openings for risers in mechanical bays.

B. To prevent accidental liquid spills from passing to a lower level, provide the following:
   1. For sleeves: Extend sleeve 25 mm (1 inch) above finished floor and provide sealant for watertight joint.
   2. For blocked out floor openings: Provide 40 mm (1-1/2 inch) angle set in silicone adhesive around opening.
   3. For drilled penetrations: Provide 40 mm (1-1/2 inch) angle ring or square set in silicone adhesive around penetration.

C. Penetrations through beams or ribs are prohibited, but may be installed in concrete beam flanges. Any deviation from these requirements must receive prior approval of COR.

D. Sheet Metal, Plastic, or Moisture-resistant Fiber Sleeves: Provide for pipe passing through floors, interior walls, and partitions, unless brass or steel pipe sleeves are specifically called for below.

E. Cast Iron or Zinc Coated Pipe Sleeves: Provide for pipe passing through exterior walls below grade. Make space between sleeve and pipe watertight with a modular or link rubber seal. Seal shall be applied at both ends of sleeve.

F. Galvanized Steel or an alternate Black Iron Pipe with asphalt coating Sleeves: Provide for pipe passing through concrete beam flanges, except where brass pipe sleeves are called for. Provide sleeve for pipe passing through floor of mechanical rooms, laundry work rooms, and animal rooms above basement. Except in mechanical rooms, connect sleeve with floor plate.

G. Brass Pipe Sleeves: Provide for pipe passing through quarry tile, terrazzo or ceramic tile floors. Connect sleeve with floor plate.

H. Sleeves are not required for wall hydrants for fire department connections or in drywall construction.

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

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

2.14 DUCT PENETRATIONS

A. Provide curbs for roof mounted piping, ductwork and equipment. Curbs shall be 450 mm (18 inches) high with continuously welded seams, built-in cant strip, interior baffle with acoustic insulation, curb bottom, hinged curb adapter.

B. Provide firestopping for openings through fire and smoke barriers, maintaining minimum required rating of floor, ceiling or wall assembly. See section 07 84 00, FIRESTOPPING.

2.15 SPECIAL TOOLS AND LUBRICANTS

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

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

C. Refrigerant Tools: Provide system charging/Evacuation equipment, gauges, fittings, and tools required for maintenance of furnished equipment.

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

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

2.16 WALL, FLOOR AND CEILING PLATES

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

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

C. Locations: Use where pipe penetrates floors, walls and ceilings in exposed locations, in finished areas only. Provide a watertight joint in spaces where brass or steel pipe sleeves are specified.

2.17 ASBESTOS

A. Materials containing asbestos are prohibited.

PART 3 - EXECUTION

3.1 GENERAL

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

3.2 ARRANGEMENT AND INSTALLATION OF EQUIPMENT AND PIPING

A. Location of piping, sleeves, inserts, hangers, and equipment, access provisions shall be coordinated with the work of all trades. The coordination/shop drawings shall be submitted for review. Locate piping, sleeves, inserts, hangers, ductwork and equipment clear of windows, doors, openings, light outlets, and other services and utilities. Equipment coordination/shop drawings shall be prepared to coordinate proper location and personnel access of all facilities. The drawings shall be submitted for review. Follow manufacturer's published recommendations for installation methods not otherwise specified.

B. Operating Personnel Access and Observation Provisions: Select and arrange all equipment and systems to provide clear view and easy access, without use of portable ladders, for maintenance and operation of all devices including, but not limited to: all equipment items, valves, filters, strainers, transmitters, sensors, control devices. All gauges and indicators shall be clearly visible by personnel standing on the floor or on permanent platforms. Do not reduce or change maintenance and operating space and access provisions that are shown on the contract documents.

C. Equipment and Piping Support: Coordinate structural systems necessary for pipe and equipment support with pipe and equipment locations to permit proper installation.

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

E. Cutting Holes:

1. Cut holes through concrete and masonry by rotary core drill. Pneumatic hammer, impact electric, and hand or manual hammer type drill is prohibited, except as permitted by COR where working area space is limited.
2. Locate holes to avoid interference with structural members such as slabs, columns, ribs, beams or reinforcing. Holes shall be laid out in advance and drilling done only after approval by COR. If the Contractor considers it necessary to drill through structural members, this matter shall be referred to COR for approval.
3. Do not penetrate membrane waterproofing.

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

G. Electrical Interconnection of Instrumentation or Controls: This generally not shown but must be provided. This includes interconnections of sensors, transmitters, transducers, control devices, control and instrumentation panels, instruments and computer workstations. Devices shall be located so they are easily accessible for testing, maintenance, calibration, etc. The COR has the final determination on what is accessible and what is not. Comply with NFPA 70.

H. Protection and Cleaning:

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

I. Concrete and Grout: Use concrete and non-shrink grout 20 MPa (3000 psig) minimum, specified in Section 03 30 00, CAST-IN-PLACE CONCRETE.

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

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 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.

M. Work in Animal Research Areas: Seal all pipe and duct penetrations with silicone sealant to prevent entrance of insects.

N. Switchgear/Electrical Equipment Drip Protection: Every effort shall be made to eliminate the installation of pipe above electrical and data/telephone switchgear. If this is not possible, encase pipe in a second pipe with a minimum of joints. Installation of piping, ductwork, leak protection apparatus or other installations foreign to the electrical installation shall not be located in the space equal to the width and depth of the equipment and extending from to a height of 1.8 m (6 feet) above the equipment or to ceiling structure, whichever is lower (NFPA 70).

O. Inaccessible Equipment:

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

2. The term "conveniently accessible" is defined as capable of being reached without the use of ladders, or without climbing or crawling under or over obstacles such as, but not limited to motors, fans, pumps, belt guards, transformers, high voltage lines, conduit and raceways, piping, hot surfaces, and ductwork. The COR has final determination on whether an installation meets this requirement or not.

3.3 TEMPORARY PIPING AND EQUIPMENT

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

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

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

3.4 RIGGING

A. Design is based on application of available equipment. Openings in building structures are planned to accommodate design scheme.

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

C. Close all openings in the building when not required for rigging operations to maintain proper environment in the facility for Government operation and maintenance of service.

D. Contractor shall provide all facilities required to deliver specified equipment and place on foundations. Attachments to structures for rigging purposes and support of equipment on structures shall be Contractor's full responsibility. Upon request, the Government will check structure adequacy and advise Contractor of recommended restrictions.

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

F. Follow approved rigging plan.

G. Restore building to original condition upon completion of rigging work.

3.5 PIPE AND EQUIPMENT SUPPORTS

A. Where hanger spacing does not correspond with joist or rib spacing, use structural steel channels designed by a structural engineer, secured directly to joist and rib structure that will correspond to the required hanger spacing, and then suspend the equipment and piping from the channels. Drill or burn holes in structural steel only with the prior approval of the COR.

B. Use of chain pipe supports; wire or strap hangers; wood for blocking, stays and bracing; or, hangers suspended from piping above are prohibited. Replace or thoroughly clean rusty products and paint with zinc primer.

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

D. HVAC Horizontal Pipe Support Spacing: Refer to MSS SP-58. Provide additional supports at valves, strainers, in-line pumps and other heavy components. Provide a support within one foot of each elbow.

E. HVAC Vertical Pipe Supports:
   1. Up to 150 mm (6-inch pipe), 9 m (30 feet) long, bolt riser clamps to the pipe below couplings, or welded to the pipe and rests supports securely on the building structure.
   2. Vertical pipe larger than the foregoing, support on base elbows or tees, or substantial pipe legs extending to the building structure.

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

G. Floor Supports:
   1. Provide concrete bases, concrete anchor blocks and pedestals, and structural steel systems for support of equipment and piping. Concrete bases and structural systems shall be anchored and doweled to resist forces under operating and seismic conditions (if applicable) without excessive displacement or structural failure.
   2. Bases and supports shall not be located and installed until equipment mounted thereon has been approved. Bases shall be sized to match equipment mounted thereon plus 50 mm (2 inch) excess on all edges. Chiller foundations shall have horizontal dimensions that exceed chiller base frame dimensions by at least 150 mm (6 inches) on all sides. Structural contract documents shall be reviewed for additional requirements. Bases shall be neatly finished and

smoothed, shall have chamfered edges at the top, and shall be suitable for painting.

3. All equipment shall be shimmed, leveled, firmly anchored, and grouted with epoxy grout. Anchor bolts shall be placed in sleeves, anchored to the bases. Fill the annular space between sleeves and bolts with a granular material to permit alignment and realignment.
4. For seismic anchoring, refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

3.6 MECHANICAL DEMOLITION

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

B. In an operating facility, maintain the operation, cleanliness and safety. Government personnel will be carrying on their normal duties of operating, cleaning and maintaining equipment and plant operation. Confine the work to the immediate area concerned; maintain cleanliness and wet down demolished materials to eliminate dust. Debris accumulated in the area to the detriment of plant operation is prohibited. Perform all flame cutting to maintain the fire safety integrity of this plant. Adequate fire extinguishing facilities shall be available at all times. Perform all work in accordance with recognized fire protection standards. Inspection will be made by personnel of the VAMC, and Contractor shall follow all directives of the COR with regard to rigging, safety, fire safety, and maintenance of operations.

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

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

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.

B. In addition, the following special conditions apply:

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

2. The following material and equipment shall not be painted:

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

   b. Control and interlock devices.

   c. Regulators.

   d. Pressure reducing valves.

   e. Control valves and thermostatic elements.

   f. Lubrication devices and grease fittings.

   g. Copper, brass, aluminum, stainless steel and bronze surfaces.

   h. Valve stems and rotating shafts.

   i. Pressure gauges and thermometers.

   j. Glass.

k. Nameplates.

3. Control and instrument panels shall be cleaned, damaged surfaces repaired, and shall be touched-up with matching paint obtained from panel manufacturer.
4. Pumps, 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. This may include painting exposed metals where hangers were removed or where equipment was moved or removed.
6. Paint shall withstand the following temperatures without peeling or discoloration:
   a. Condensate and Feedwater: 38 degrees C (100 degrees F) on insulation jacket surface and 121 degrees C (250 degrees F) on metal pipe surface.
   b. Steam: 52 degrees C (125 degrees F) on insulation jacket surface and 190 degrees C (374 degrees F) on metal pipe surface.
7. Final result shall be smooth, even-colored, even-textured factory finish on all items. Completely repaint the entire piece of equipment if necessary to achieve this.
8. Lead based paints are prohibited.

3.8 IDENTIFICATION SIGNS

A. Provide laminated plastic signs, with engraved lettering not less than 5 mm (3/16 inch) high, designating functions, for all equipment, switches, motor controllers, relays, meters, control devices, including automatic control valves. Nomenclature and identification symbols shall correspond to that used in maintenance manual, and in diagrams specified elsewhere. Attach by chain, adhesive, or screws.

B. Factory Built Equipment: Metal plate, securely attached, with name and address of manufacturer, serial number, model number, size, performance.

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

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

3.9 MOTOR AND DRIVES

A. Use synchronous belt drives only on equipment controlled by soft starters or variable frequency drive motor controllers without a bypass contactor. Use V-belt drives on all other applications.

B. Alignment of V-Belt Drives: Set driving and driven shafts parallel and align so that the corresponding grooves are in the same plane.

C. Alignment of Synchronous Belt Drives: Set driving and driven shafts parallel and align so that the corresponding pulley flanges are in the same plane.

D. Alignment of Direct-Connect Drives: Securely mount motor in accurate alignment so that shafts are per coupling manufacturer’s tolerances when both motor and driven machine are operating at normal temperatures.

3.10 LUBRICATION

A. All equipment and devices requiring lubrication shall be lubricated prior to initial operation. Field-check all devices for proper lubrication.

B. All devices and equipment shall be equipped with required lubrication fittings or devices. A minimum of 0.95 liter (1 quart) of oil and 0.45 kg (1 pound) of grease of manufacturer's recommended grade and type for each different application shall be provided; also provide 12 grease sticks for lubricated plug valves. Deliver all materials to COR in unopened containers that are properly identified as to application.

C. All lubrication points shall be accessible without disassembling equipment, except to remove access plates.

D. All lubrication points shall be extended to one side of the equipment.

3.11 STARTUP, TEMPORARY OPERATION AND TESTING

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

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

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

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

3.12 OPERATING AND PERFORMANCE TESTS

A. Prior to the final inspection, perform required tests as specified in Section 01 00 00, GENERAL REQUIREMENTS Article, TESTS, and in individual Division 23 specification sections and submit the test reports and records to the COR.

B. Should evidence of malfunction in any tested system, or piece of equipment or component part thereof, occur during or as a result of tests, make proper corrections, repairs or replacements, and repeat tests at no additional cost or time to the Government.

C. When completion of certain work or system occurs at a time when final control settings and adjustments cannot be properly made to make performance tests, then conduct such performance tests and finalize control settings for heating systems and for cooling systems respectively during first actual seasonal use of respective systems following completion of work. Rescheduling of these tests shall be requested in writing to COR for approval.

D. No adjustments may be made during the acceptance inspection. All adjustments shall have been made by this point.

E. Perform tests as required for commissioning provisions in accordance with Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS and Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

3.13 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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

3.14 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer’s technical representative for 4 hours to instruct each VA personnel responsible in operation and maintenance of the system.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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

PART 1 - GENERAL

1.1 DESCRIPTION

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

B. A complete listing of common acronyms and abbreviations are included in Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION, Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

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

C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

D. Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION.

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

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

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

H. Section 26 29 11, MOTOR CONTROLLERS.

1.3 APPLICABLE PUBLICATIONS

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

B. American Bearing Manufacturers Association (ABMA):

9–2015..................Load Ratings and Fatigue Life for Ball Bearings

11-2014.................Load Ratings and Fatigue Life for Roller Bearings

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

90.1-2013...............Energy Efficient Design of New Buildings Except Low-Rise Residential Buildings

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

112-2017................Standard Test Procedure for Polyphase Induction Motors and Generators

841-2009................IEEE Standard for Petroleum and Chemical Industry-Premium-Efficiency, Severe-Duty, Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors--Up to and Including 370 kW (500 hp)

E. National Electrical Manufacturers Association (NEMA):

MG 1-2019...............Motors and Generators

MG 2–2014...............Safety Standard for Construction and Guide for Selection, Installation and Use of Electric Motors and Generators

250-2014................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 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT”, with applicable paragraph identification.

C. Submit motor submittals with driven equipment.

D. Shop Drawings:

1. Provide documentation to demonstrate compliance with contract documents.
2. Motor nameplate information shall be submitted including electrical ratings, efficiency, bearing data, power factor, frame size, dimensions, mounting details, materials, horsepower, voltage, phase, speed (RPM), enclosure, starting characteristics, torque characteristics, code letter, full load and locked rotor current, service factor, and lubrication method.

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

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

G. Certification: Two weeks prior to final inspection, unless otherwise noted, certification shall be submitted to the COR stating that the motors have been properly applied, installed, adjusted, lubricated, and tested.

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

I. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

1.5 AS-BUILT DOCUMENTATION

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

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

C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the 'third party testing company' requirement. Provide record drawings as follows:
   1. As-built drawings are to be provided, with a copy of them on AutoCAD provided on CD or DVD. The CAD drawings shall use multiple line layers with a separate individual layer for each system.

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

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

PART 2 - PRODUCTS

2.1 MOTORS

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

B. For severe duty TEFC motors, IEEE 841 shall apply.

C. All material and equipment furnished, and installation methods shall conform to the requirements of Section 26 29 11, MOTOR CONTROLLERS; and Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES.

Provide all electrical wiring, conduit, and devices necessary for the proper connection, protection and operation of the systems. Provide premium efficiency type motors. Unless otherwise specified for a particular application, use electric motors with the following requirements.

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

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

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

F. Voltage ratings shall be as follows:

   1. Single phase:

      a. Motors connected to 120-volt systems: 115 volts.

      b. Motors connected to 208-volt systems: 200 volts.

      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 240-volt systems: 230 volts.

      d. Motors, 74.6 kW (100 hp) or larger, connected to 480-volt systems: 460 volts.

      e. Motors connected to high voltage systems (Over 600V): Shall conform to NEMA MG 1 for connection to the nominal system voltage shown on the drawings.

G. Number of phases shall be as follows:

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

   2. Motors, 373 W (1/2 hp) and larger: 3 phase.

   3. Exceptions:

      a. Hermetically sealed motors.

b. Motors for equipment assemblies, less than 746 W (1 hp), may be single phase provided the manufacturer of the proposed assemblies cannot supply the assemblies with three phase motors.

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

I. Motor designs, as indicated by the NEMA code letters, shall be coordinated with the connected loads to assure adequate starting, acceleration, and running torque without exceeding nameplate ratings or considering service factor.

J. Motor Enclosures:

1. Shall be the NEMA types as specified and/or shown in the Contract Documents.
2. Where the types of motor enclosures are not shown on the drawings, they shall be the NEMA types per NEMA 250, which are most suitable for the environmental conditions where the motors are being installed. Enclosure requirements for certain conditions are as follows:
    a. Motors located outdoors, indoors in wet or high humidity locations, or in unfiltered airstreams shall be totally enclosed type.
    b. Where motors are located in an NEC 511 classified area, provide TEFC explosion proof motor enclosures.
    c. Where motors are located in a corrosive environment, provide TEFC enclosures with corrosion resistant finish.
3. Enclosures shall be primed and finish coated at the factory with manufacturer's prime coat and standard finish.

K. Electrical Design Requirements:

1. Motors shall be continuous duty.
2. The insulation system shall be rated minimum of Class B, 130 degrees C (266 degrees F).
3. The maximum temperature rise by resistance at rated power shall not exceed Class B limits, 80 degrees C (176 degrees F).
4. The speed/torque and speed/current characteristics shall comply with NEMA Design A or B, as specified.

5. Motors shall be suitable for full voltage starting, unless otherwise noted. Coordinate motor features with applicable motor controllers.
6. Motors for variable frequency drive applications shall adhere to NEMA MG 1, Part 30, Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General-Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both, or NEMA MG 1, Part 31, Definite-Purpose Inverter-Fed Polyphase Motors.

L. Mechanical Design Requirements:

1. Bearings shall be rated in accordance with ABMA 9 or ABMA 11 for a minimum fatigue life of 26,280 hours for belt-driven loads and 100,000 hours for direct-drive loads based on L10 (Basic Rating Life) at full load direct coupled, except vertical high thrust motors which require a 40,000 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.

M. Special Requirements:
   1. Where motor power requirements of equipment furnished deviate from power shown on plans, provide electrical service designed under the requirements of NFPA 70 without additional cost or time to the Government.
   2. Assemblies of motors, starters, controls and interlocks on factory assembled and wired devices shall be in accordance with the requirements of this specification.
   3. Wire and cable materials specified in the electrical division of the specifications shall be modified as follows:
      a. Wiring material located where temperatures can exceed 71 degrees C (160 degrees F) shall be stranded copper with Teflon FEP insulation with jacket. This includes wiring on the boilers.
      b. Other wiring at boilers and to control panels shall be NFPA 70 designation THWN.
      c. Provide shielded conductors or wiring in separate conduits for all instrumentation and control systems where recommended by manufacturer of equipment.
   4. Select motor sizes so that the motors do not operate into the service factor at maximum required loads on the driven equipment. Motors on pumps shall be sized for non-overloading at all points on the pump performance curves.
   5. Motors utilized with variable frequency drives shall be rated “inverter-duty” per NEMA MG 1, Part 31, Definite-Purpose Inverter-Fed Polyphase Motors. Provide motor shaft grounding apparatus that will protect bearings from damage from stray currents.

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

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

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

P. Minimum Power Factor at Full Load and Rated Voltage: 90 percent at 1200 RPM, 1800 RPM, and 3600 RPM. Power factor correction capacitors shall be provided unless the motor meets the 0.90 requirement without it or if the motor is controlled by a variable frequency drive. The power factor correction capacitors shall be able to withstand high voltage transients and power line variations without breakdown.

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

Polyphase Open Motors Average full load efficiency				Capacitor-start capacitor-run and capacitor-start induction run open motors Average full load efficiency			
Rating kW (hp)	**6 poles**	**4 poles**	**2 poles**	**Rating kW (hp)**	**6 poles**	**4 poles**	**2 poles**
0.18 (0.25)	67.5	69.5	65.6	0.18 (0.25)	62.2	68.5	66.6
0.25 (0.33)	71.4	73.4	69.5	0.25 (0.33)	66.6	72.4	70.5
0.37 (0.5)	75.3	78.2	73.4	0.37 (0.5)	76.2	76.2	72.4
0.55 (0.75)	81.7	81.1	76.8	0.55 (0.75)	80.2	81.8	76.2

PART 3 - EXECUTION

3.1 INSTALLATION

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

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

3.2 FIELD TESTS

A. All tests shall be witnessed by the Commissioning Agent or by the COR.

B. Perform an electric insulation resistance Test using a megohmmeter on all motors after installation, before startup. All shall test free from grounds.

C. Perform Load test in accordance with IEEE 112, Test Method B, to determine freedom from electrical or mechanical defects and compliance with performance data.

D. Insulation Resistance: Not less than one-half meg-ohm between stator conductors and frame, to be determined at the time of final inspection.

E. All test data shall be complied into a report form for each motor and provided to the contracting officer or their representative.

3.3 STARTUP AND TESTING

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

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

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

3.4 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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

3.5 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer’s technical representative for 4 hours. (4) additional hours are required for boiler and controls, to instruct each VA personnel responsible in operation and maintenance of the system.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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SECTION 23 05 41
NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the application of noise control measures, seismic restraint for equipment and vibration control techniques to boiler plant rotating equipment and parts including chillers, cooling towers, boilers, pumps, fans, compressors, motors and steam turbines.

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

1.2 RELATED WORK

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

B. Section 23 05 10, COMMON WORK RESULTS FOR HVAC.

C. Section 23 31 00, HVAC DUCTS and CASINGS.

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

1.3 QUALITY ASSURANCE

A. Refer to article, QUALITY ASSURANCE in specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.

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
Audio Speech Pathology	25
Audio Suites	25
Auditoriums, Theaters	35-40
Bathrooms and Toilet Rooms	40
Chapels	35
Conference Rooms	35
Corridors (Nurse Stations)	40
Corridors(Public)	40
Dining Rooms, Food Services/ Serving	40
Examination Rooms	35
Gymnasiums	50
Kitchens	50

Laboratories (With Fume Hoods)	45 to 55
Laundries	50
Lobbies, Waiting Areas	40
Locker Rooms	45
Offices, Large Open	40
Offices, Small Private	35
Operating Rooms	40
Patient Rooms	35
Phono/Cardiology	25
Recreation Rooms	40-45
Shops	50
SPD (Decontamination and Clean Preparation)	45
Therapeutic Pools	45
Treatment Rooms	35
Warehouse	50
X-Ray and General Work Rooms	40

2. For equipment which has no sound power ratings scheduled on the plans, the contractor shall select equipment such that the foregoing noise criteria, local ordinance noise levels, and OSHA requirements are not exceeded. Selection procedure shall be in accordance with ASHRAE Fundamentals Handbook, Chapter 8, 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 10, 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 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. Seismic restraint provisions and bolting.
4. 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.

D. Seismic Requirements: Submittals are required for all equipment anchors, supports and seismic restraints. Submittals shall include weights, dimensions, standard connections, and manufacturer's certification that all specified equipment will withstand seismic Lateral Force requirements as shown on drawings.

1.5 APPLICABLE PUBLICATIONS

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

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

Handbook 2017..........Fundamentals Handbook, Chapter 8, Sound and Vibration

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

A123/A123M-2017.........Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

A307-2016...............Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength

D2240-05(2010).........Standard Test Method for Rubber Property - Durometer Hardness

D. Manufacturers Standardization (MSS):

SP-58-2018..............Pipe Hangers and Supports-Materials, Design and Manufacture

E. Occupational Safety and Health Administration (OSHA):

29 CFR 1960.95..........Occupational Noise Exposure

F. American Society of Civil Engineers (ASCE):

ASCE 7-2017.............Minimum Design Loads for Buildings and Other Structures.

G. American National Standards Institute / Sheet Metal and Air Conditioning Contractor’s National Association (ANSI/SMACNA):

001-2008................Seismic Restraint Manual: Guidelines for Mechanical Systems, 3rd Edition.

H. International Code Council (ICC):

IBC 2018................International Building Code.

I. Department of Veterans Affairs (VA):

H-18-8 2016.............Seismic Design Requirements.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Type of isolator, base, and minimum static deflection shall be as required for each specific equipment application as recommended by isolator or equipment manufacturer but subject to minimum requirements indicated herein and in the schedule on the drawings.

B. Elastometric Isolators shall comply with ASTM D2240 and be oil resistant neoprene with a maximum stiffness of 60 durometer and have a straight-line deflection curve.

C. Exposure to weather: Isolator housings to be either hot dipped galvanized or powder coated to ASTM B117 salt spray testing standards. Springs to be powder coated or electro galvanized. All hardware to be electro galvanized. In addition, provide limit stops to resist wind velocity. Velocity pressure established by wind shall be calculated in accordance with section 1609 of the International Building Code. A minimum wind velocity of 75 mph shall be employed.

D. Uniform Loading: Select and locate isolators to produce uniform loading and deflection even when equipment weight is not evenly distributed.

E. Color code isolators by type and size for easy identification of capacity.

2.2 SEISMIC RESTRAINT REQUIREMENTS FOR 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.
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. Isolators shall have a minimum seismic rating of one G.
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 ¼’ 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 6 mm (1/4 inch). Air gap between hard and resilient material shall be not less than 3 mm (1/8 inch) nor more than 6 mm (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 6 mm (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 1/12 of longest base dimension but not less than 100 mm (4 inches). Where rails are used with neoprene mounts for small fans or close coupled pumps, extend rails to compensate overhang of housing.

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 1/12 of longest base dimension, but not less than 100 mm (four inches).

C. Inertia Base (Type I): Base shall be a reinforced concrete inertia base. Pour concrete into a welded steel channel frame, incorporating prelocated 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 150 mm (six inches). Form shall include 13-mm (1/2-inch) reinforcing bars welded in place on minimum of 203 mm (eight inch) centers running both ways in a layer 40 mm (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 2 mm (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 6 mm (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

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

2.6 ACOUSTICAL ENCLOSURES IN MECHANICAL ROOMS

A. Provide where shown on the drawings. Enclosures shall be removable and sectional, of a size and weight that sections can be readily handled with typical lifting and moving equipment available in the equipment room. Enclosures must contain access openings, observation ports, lights, and ventilation where required for normal operation, observation and servicing.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Vibration Isolation:

1. No metal-to-metal contact will be permitted between fixed and floating parts.
2. Connections to Equipment: Allow for deflections equal to or greater than equipment deflections. Electrical, drain, piping connections, and other items made to rotating or reciprocating equipment (pumps, compressors, etc.) which rests on vibration isolators, shall be isolated from building structure for first three hangers or supports with a deflection equal to that used on the corresponding equipment.
3. Common Foundation: Mount each electric motor on same foundation as driven machine. Hold driving motor and driven machine in positive rigid alignment with provision for adjusting motor alignment and belt tension. Bases shall be level throughout length and width. Provide shims to facilitate pipe connections, leveling, and bolting.
4. Provide heat shields where elastomers are subject to temperatures over 38 degrees C (l00 degrees F).
5. Extend bases for pipe elbow supports at discharge and suction connections at pumps. Pipe elbow supports shall not short circuit pump vibration to structure.
6. Non-rotating equipment such as heat exchangers and convertors shall be mounted on isolation units having the same static deflection as

the isolation hangers or support of the pipe connected to the equipment.

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

3.2 ADJUSTING

A. Adjust vibration isolators after piping systems are filled and equipment is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4inch (6-mm) movement during start and stop.

D. Adjust active height of spring isolators.

E. Adjust snubbers according to manufacturer's recommendations.

F. Adjust seismic restraints to permit free movement of equipment within normal mode of operation.

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

3.3 COMMISSIONING

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

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

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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
REFRIGERATION MACHINES															
ABSORPTION	---	D	0.3	---	SP	0.8	---	SP	1.5	---	SP	1.5	---	SP	2.0
PACKAGED HERMETIC	---	D	0.3	---	SP	0.8	---	SP	1.5	---	SP	1.5	R	SP	2.5
OPEN CENTRIFUGAL	B	D	0.3	B	SP	0.8	---	SP	1.5	B	SP	1.5	B	SP	3.5
RECIPROCATING:															
ALL	---	D	0.3	---	SP	0.8	R	SP	2.0	R	SP	2.5	R	SP	3.5
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	---
CLOSE COUPLED: 2 HP & OVER	---	---	---	I	S	0.8	I	S	1.5	I	S	1.5	I	S	2.0

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
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
BASE MOUNTED	UP TO 10 HP	---	---	---	---	D,L, W	---	---	D,L, W	---	---	D,L, W	---	---	D,L, W	---
	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

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
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
COOLING TOWERS															
UP TO 500 RPM	---	---	---	---	SP	2.5	---	SP	2.5	---	SP	2.5	---	SP	3.5
501 RPM & OVER	---	---	---	---	SP	0.75	---	SP	0.75	---	SP	1.5	---	SP	2.5
INTERNAL COMBUSTION ENGINES															
UP TO 25 HP	I	N	0.75	I	N	1.5	I	S	2.5	I	S	3.5	I	S	4.5
30 THRU 100 HP	I	N	0.75	I	N	1.5	I	S	2.5	I	S	3.5	I	S	4.5
125 HP & OVER	I	N	0.75	I	N	1.5	I	S	2.5	I	S	3.5	I	S	4.5
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

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
501 RPM & OVER	---	---	---	---	H, THR	0.8	---	H, THR	0.8	---	H,THR	0.8	---	H,THR	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
IN-LINE CENTRIFUGAL AND VANE AXIAL FANS, FLOOR MOUNTED: (APR 9)															
UP THRU 50 HP:															
UP TO 300 RPM	---	D	---	R	S	2.5	R	S	2.5	R	S	2.5	R	S	3.5
301 - 500 RPM	---	D	---	R	S	2.0	R	S	2.0	R	S	2.5	R	S	2.5
501 - & OVER	---	D	---	---	S	1.0	---	S	1.0	R	S	2.0	R	S	2.5
60 HP AND OVER:															
301 - 500 RPM	R	S	1.0	R	S	2.0	R	S	2.0	R	S	2.5	R	S	3.5
501 RPM & OVER	R	S	1.0	R	S	2.0	R	S	2.0	R	S	2.0	R	S	2.5

END

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SECTION 23 05 51
NOISE AND VIBRATION CONTROL FOR BOILER PLANT

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies the application of noise control measures, seismic restraint for equipment and vibration control techniques to boiler plant rotating equipment including pumps, fans, compressors, motors and steam turbines.

B. A complete listing of all common acronyms and abbreviations are included in Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

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

C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

D. Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION.

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

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

G. Section 23 08 11, DEMONSTRATIONS AND TESTS FOR BOILER PLANT.

H. Section 23 21 11, BOILER PLANT PIPING 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. Where conflicts occur these specifications and the VHA standard will govern.

B. American Boiler Manufacturers Association (ABMA):
304-1995................Measurement of Sound from Steam Generators

C. American Society of Civil Engineers (ASCE):
7-2016..................Minimum Design Loads for Buildings and Other Structures

D. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE):
Fundamentals-2017.......ASHRAE Handbook - Fundamentals, Chapter 8 Sound and Vibration

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

A307-2019...............Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 PSI Tensile Strength

B117-2018...............Standard Practice for Operating Salt Spray (Fog) Apparatus

D2240-2015..............Standard Test Method for Rubber Property - Durometer Hardness

F. Associated Air Balance Council (AABC):

2015....................National Standards for Total System Balance, 7th Edition

G. International Code Council (ICC):

IBC-2018................International Building Code

H. International Standards Organization (ISO):

1940-1-2003.............Mechanical Vibration – Balance Quality Requirements for Rotors in a Constant (Rigid) State – Part 1: Specification and Verification of Balance Tolerances

I. National Environmental Balancing Bureau (NEBB):

2015....................Procedural Standard for the Measurement of Sound and Vibration, 3rd Edition

J. Manufacturers Standardization (MSS):

SP-58-2018..............Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation

K. Occupational Safety and Health Administration (OSHA):

29 CFR 1910.95..........Occupational Noise Exposure

L. Sheet Metal and Air Conditioning Contractor’s National Association (SMACNA):

001-2008................Seismic Restraint Manual: Guidelines for Mechanical Systems, 3rd Edition

M. Department of Veterans Affairs (VA):

H-18-8-2019.............Seismic Design Requirements

1.4 SUBMITTALS

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

B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 23 05 51, NOISE AND VIBRATION CONTROL FOR BOILER PLANT", with applicable paragraph identification.

C. Include noise and vibration control devices with the equipment submittals.

D. Certification, training, and project experience resume of field shaft alignment and or dynamic machine balancing technicians.

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

F. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replacement parts, and troubleshooting guide:

1. Include complete list indicating all components of the systems.
2. Include complete diagrams of the internal wiring for each item of equipment.
3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

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

1.5 QUALITY ASSURANCE

A. 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
Locker Rooms	45

Offices, Large Open	40
Offices, Small Private	35
Shops	50
Warehouse	50

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 8, Sound and Vibration.
3. An allowance, not to exceed 5 dB, may be added to the measured value to compensate for the variation of the room attenuating effect between room test condition prior to occupancy and design condition after occupancy which may include the addition of sound absorbing material, such as, furniture. This allowance may not be taken after occupancy. The room attenuating effect is defined as the difference between sound power level emitted to room and sound pressure level in room.
4. In absence of specified measurement requirements, measure equipment noise levels three feet from equipment and at an elevation of maximum noise generation.

B. 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 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION.
3. Ductwork: Refer to specification Section 23 31 00, HVAC DUCTS AND CASINGS.

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

D. AABC OR NEBB certified vibration and sound measurement professional shall certify final measurements. See Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.

1.6 AS-BUILT DOCUMENTATION

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

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

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

1. As-built drawings are to be provided, with a copy of them on AutoCAD provided on CD or DVD. The CAD drawings shall use multiple line layers with a separate individual layer for each system.

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

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

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Type of isolator, base, and minimum static deflection shall be as required for each specific equipment application as recommended by isolator or equipment manufacturer but subject to minimum requirements indicated herein and in the Selection Guide for Vibration Isolators Table at the end of this section of specifications.

B. Elastomeric isolators shall comply with ASTM D2240 and be oil resistant neoprene with a maximum stiffness of 60 durometer and have a straight-line deflection curve.

C. Exposure to Weather: Isolator housings to be either hot dipped galvanized or powder coated to ASTM B117 salt spray testing standards. Springs to be powder coated or electro galvanized. All hardware to be electro galvanized. In addition, provide limit stops to resist wind velocity. Velocity pressure established by wind shall be calculated in accordance with Section 1609 of the International Building Code (IBC). A minimum wind velocity of 120 km/h (75 mph) shall be employed.

D. Uniform Loading: Select and locate isolators to produce uniform loading and deflection even when equipment weight is not evenly distributed.

E. Color code isolators by type and size for easy identification of capacity.

2.2 SEISMIC RESTRAINT REQUIREMENTS FOR EQUIPMENT

A. Bolt pad mounted equipment, without vibration isolators, to the floor or other support using ASTM A307 standard bolting material.

B. Floor mounted equipment, with vibration isolators, Type SS. Where Type N isolators are used provide channel frame base horizontal restraints bolted to the floor, or other support, on all sides of the equipment. Size and material required for the base shall be as recommended by the isolator manufacturer.

C. On all sides of suspended equipment, provide bracing for rigid supports and provide restraints for resiliently supported equipment.

2.3 VIBRATION ISOLATORS

A. Floor Mountings:

1. 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.

4. Spring Isolators with Vertical Limit Stops (Type SP):
   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.
   c. 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. Isolators shall have a minimum seismic rating of one G.
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. Size pads for a maximum load of 345 kPa (50 psig).
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 psig).

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): 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. 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 6 mm (1/4 inch) 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 6 mm (1/4 inch). Air gap between hard and resilient material shall be not less than 3.2 mm (1/8 inch) nor more than 6 mm (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 6 mm (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 1/12 of longest base dimension but not less than 100 mm (4 inches). Where rails are used with neoprene mounts for small fans or close coupled pumps, extend rails to compensate overhang of housing.

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 1/12 of longest base dimension, but not less than 100 mm (4 inches).

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 base dimension but not less than 150 mm (6 inches). Form shall include 15 mm (1/2 inch) reinforcing bars welded in place on minimum of 200 mm (8 inch) centers running both ways in a layer 40 mm (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 1.6 mm (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 6 mm (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.

PART 3 - EXECUTION

3.1 INSTALLATION

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

B. Vibration Isolation:

1. No metal-to-metal contact will be permitted between fixed and floating parts.
2. Connections to Equipment: Allow for deflections equal to or greater than equipment deflections. Electrical, drain, piping connections, and other items made to rotating or reciprocating equipment (pumps, compressors, etc.) which rests on vibration isolators, shall be isolated from building structure for first three hangers or supports with a deflection equal to that used on the corresponding equipment.
3. Common Foundation: Mount each electric motor on same foundation as driven machine. Hold driving motor and driven machine in positive rigid alignment with provision for adjusting motor alignment and belt tension. Bases shall be level throughout length and width. Provide shims to facilitate pipe connections, leveling, and bolting.
4. Provide heat shields where elastomers are subject to temperatures over 38 degrees C (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.

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

3.2 ADJUSTING

A. Adjust vibration isolators after piping systems are filled and equipment is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Attach thrust limits at centerline of thrust and adjust to a maximum of 6 mm (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 BALANCING AND ALIGNMENT OF ROTATING EQUIPMENT

A. Statically and dynamically balance all pumps, fans, compressors and drivers. Align shafts of pumps, fans, and drivers to limit noise and vibration to specified values required by 29 CFR 1910.95. Level and anchor equipment as necessary to achieve and maintain alignment. Refer to Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION and Section 23 21 11, BOILER PLANT PIPING SYSTEMS. Work shall comply with manufacturer’s instructions and/or recommendations and with ISO 1940-1 for the type of equipment which is Grade 6.3 for most equipment in the boiler plant.

3.4 VIBRATION TESTS ON ROTATING EQUIPMENT

A. Perform vibration tests on all pumps, fans, compressors and drivers during the pretest of the equipment. Refer to Section 23 08 11, DEMONSTRATIONS AND TESTS FOR BOILER PLANT. Contractor shall notify COR at least 10 working days prior to commencing test. Tests shall be conducted by an experienced technician in the presence of the COR.

B. Perform tests at each bearing in axial, horizontal, and vertical positions.

C. rms vibration velocity shall not exceed 0.0025 m/s (0.10 inch per second). Correct the cause of excessive vibration and provide retest.

D. Test instruments furnished by contractor:

1. Portable with output capability to print data.

2. Frequency range, 600 to 150,000 CPM minimum.
3. Amplitude range, 0 to 2.54 m/s (0 to 100 inches per second).
4. Sensitivity, 0.00013 m/s (0.005 inch per second).
5. Frequency filter "out" for tests.

E. Submit tabulated vibration readings to the COR.

3.5 SOUND LEVELS

A. Sound level limitations apply to all burners, fans, blowers, pumps, compressors, control valves, pressure reducing valves, motors, and turbines.

B. Sound levels shall not exceed 85 dB(A) when measured 1375 mm (4.5 feet) above the floor and 900 mm (3 feet) horizontally from each surface of the smallest imaginary rectangular box which could completely enclose the entire unit which contains the sound source. Sound level limitations apply to the operation of the equipment at all loads within the equipment requirements.

C. Tests will be performed by the Government using a standard sound level meter on the "A" scale, slow response. At the option and expense of the Government, a testing company may be employed to conduct tests using methods conforming to ABMA 304.

D. If sound levels exceed requirements, modify or replace the equipment as necessary to achieve required sound levels and other specified requirements.

1. Submit all proposed modifications or replacements for review prior to starting the work.
2. After completing the work, provide complete retest of equipment operation and performance.

3.6 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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

3.7 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
BASE MOUNTED	UP TO 10 HP	---	---	---	---	D,L, W	---	---	D,L, W	---	---	D,L, W	---	---	D,L, W	---
	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

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
	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
INTERNAL COMBUSTION ENGINES																
UP TO 25 HP		I	N	0.75	I	N	1.5	I	S	2.5	I	S	3.5	I	S	4.5
30 THRU 100 HP		I	N	0.75	I	N	1.5	I	S	2.5	I	S	3.5	I	S	4.5
125 HP & OVER		I	N	0.75	I	N	1.5	I	S	2.5	I	S	3.5	I	S	4.5
AIR HANDLING UNIT PACKAGES																

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**
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, THR	0.8	---	H, THR	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
IN-LINE CENTRIFUGAL AND VANE AXIAL FANS, FLOOR MOUNTED:															
UP THRU 50 HP:															
UP TO 300 RPM	---	D	---	R	S	2.5	R	S	2.5	R	S	2.5	R	S	3.5

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**
301 - 500 RPM	---	D	---	R	S	2.0	R	S	2.0	R	S	2.5	R	S	2.5
501 - & OVER	---	D	---	---	S	1.0	---	S	1.0	R	S	2.0	R	S	2.5
60 HP AND OVER:															
301 - 500 RPM	R	S	1.0	R	S	2.0	R	S	2.0	R	S	2.5	R	S	3.5
501 RPM & OVER	R	S	1.0	R	S	2.0	R	S	2.0	R	S	2.0	R	S	2.5

NOTES:

1. Edit the Table above to suit where isolator, other than those shown, are used, such as for seismic restraints and position limit stops.
2. For suspended floors lighter than 100 mm (4 inch) thick concrete, select deflection requirements from next higher span.
3. For separate steam plant building on grade, pump isolators may be omitted.
4. For projects in seismic areas, use only SS & DS type isolators and snubbers.
5. For floor mounted in-line centrifugal blowers (ARR 1): use "B" type in lieu of "R" type base.
6. Suspended: Use "H" isolators of same deflection as floor mounted.

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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.
   9. Document critical paths of flow on reports.

B. Definitions:
   1. Basic TAB used in this Section: Chapter 39, "Testing, Adjusting and Balancing" of 2019 ASHRAE Handbook, "HVAC Applications".
   2. TAB: Testing, Adjusting and Balancing; the process of checking and adjusting HVAC systems to meet design objectives.
   3. AABC: Associated Air Balance Council.
   4. NEBB: National Environmental Balancing Bureau.
   5. TABB: Testing Adjusting and Balancing Bureau
   6. SMACNA: Sheet Metal Contractors National Association
   8. Air Systems: Includes all outside air, supply air, return air, exhaust air and relief air systems.
   9. Flow rate tolerance: The allowable percentage variation, minus to plus, of actual flow rate from values (design) in the contract documents.

1.2 RELATED WORK

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

B. Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANTS and STEAM GENERATION.

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

D. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.
E. Section 23 07 11, HVAC, AND BOILER PLANT INSULATION.
F. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
G. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
H. Section 23 31 00, HVAC DUCTS AND CASINGS.

1.3 QUALITY ASSURANCE

A. Refer to Articles, Quality Assurance and Submittals, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC, Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANTS and STEAM GENERATION, and Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
B. Qualifications:
   1. TAB Agency: The TAB agency shall be a subcontractor of the General Contractor and shall report to and be paid by the General Contractor.
   2. The TAB agency shall be either a certified member of AABC, NEEB, TABB or 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 COR and submit another qualified TAB firm for approval. Any agency that has been the subject of disciplinary action by either the AABC, TABB or NEBB within the five years preceding Contract Award shall not be eligible to perform any work related to the TAB. All work performed in this Section and in other related Sections by the TAB agency shall be considered invalid if the TAB agency loses its certification prior to Contract completion, and the successor agency’s review shows unsatisfactory work performed by the predecessor agency.
   3. TAB Specialist: The TAB specialist shall be either a member of AABC or TABB or an experienced technician of the Agency certified by NEBB. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason, the Specialist loses subject certification during this period, the General Contractor shall immediately notify the COR and submit another TAB Specialist

for approval. Any individual that has been the subject of disciplinary action by either the AABC or the NEBB within the five 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, TABB 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.
   f. Shall document critical paths from the fan or pump. These critical paths are ones in which are 100% open from the fan or pump to the terminal device. This will show the least amount of restriction is being imposed on the system by the TAB firm.
5. All TAB technicians performing actual TAB work shall be experienced and must have done satisfactory work on a minimum of 3 projects comparable in size and complexity to this project. Qualifications must be certified by the TAB agency in writing. The lead technician shall be certified by AABC, TABB or NEBB

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

D. TAB Criteria:

1. One or more of the applicable AABC, NEBB,TABB or SMACNA publications, supplemented by ASHRAE Handbook "2019 HVAC Applications" Chapter 39, and requirements stated herein shall be the basis for planning, procedures, and reports.
2. Flow rate tolerance: Following tolerances are allowed. For tolerances not mentioned herein follow 2011 ASHRAE Handbook "2019 HVAC Applications", Chapter 39, as a guideline. Air Filter resistance during tests, artificially imposed, if necessary, shall be at least 100 percent of manufacturer recommended change over pressure drop values for pre-filters and after-filters.
   a. Air handling unit and all other fans, cubic meters/min (cubic feet per minute): Minus 0 percent to plus l0 percent.
   b. Air terminal units (maximum values): Minus 2 percent to plus l0 percent.
   c. Exhaust hoods/cabinets: 0 percent to plus l0 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 l0 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.
3. Systems shall be adjusted for energy efficient operation as described in PART 3.
4. Typical TAB procedures and critical path results shall be demonstrated to the COR for one air distribution system (including all fans, three terminal units, three rooms randomly selected by the COR one of which shall be a critical path) 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,NEBB or TABB publications that will be the basis of TAB work.

D. Submit Following for Review and Approval:

1. Design Review Report within 90 days for conventional design projects and within 60 days for design-build projects after the system layout on air and water side is completed by the Contractor.
2. Systems inspection report on equipment and installation for conformance with design.
3. Duct Air Leakage Test Report.
4. Systems Readiness Report.
5. Intermediate and Final TAB reports covering flow balance and adjustments, performance tests, vibration tests and sound tests.
6. Include in final reports uncorrected installation deficiencies noted during TAB and applicable explanatory comments on test results that differ from design requirements.
7. Include in each report the critical path for each balanced branch (air and hydronic. Every branch shall have at least one terminal device damper 100% open.

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

1.5 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.

B. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE):

Handbook 2019...........HVAC Applications ASHRAE Handbook, Chapter 39, Testing, Adjusting, and Balancing and Chapter 49, Sound and Vibration Control

C. Associated Air Balance Council (AABC):

7th Edition 2016 ....AABC National Standards for Total System Balance

D. National Environmental Balancing Bureau (NEBB):

9th Edition 2019 ....Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems

3rd Edition 2015 ....Procedural Standards for the Measurement of Sound and Vibration

2nd Edition 2019 ... Standard for Whole Building Technical Commissioning of New Construction

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

3rd Edition 2005 ....HVAC SYSTEMS Testing, Adjusting and Balancing

TABB- TAB Procedural Guide Current Edition

PART 2 - PRODUCTS

2.1 PLUGS

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

2.2 INSULATION REPAIR MATERIAL

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

PART 3 - EXECUTION

3.1 GENERAL

A. Refer to TAB Criteria in Article, Quality Assurance.

B. Obtain applicable contract documents and copies of approved submittals for HVAC equipment and automatic control systems.

3.2 DESIGN REVIEW REPORT

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

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 (TABB), supplemented by narrative comments, with emphasis on air handling units and fans. Check for conformance with submittals. Verify that diffuser and register sizes are correct. Check air terminal unit installation including their duct sizes and routing.

3.4 DUCT AIR LEAKAGE TEST REPORT

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

3.5 SYSTEM READINESS REPORT

A. 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 RE in standard format and forms prepared and or approved by the Commissioning Agent.

C. Verify that all items such as ductwork piping, dampers, valves, 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 50 percent of systems and equipment tested and balanced to establish satisfactory test results.

B. The TAB contractor shall provide raw data immediately in writing to the COR if there is a problem in achieving intended results before submitting a formal report.

C. If over 20 percent of readings in the intermediate report fall outside the acceptable range, the TAB report shall be considered invalid, and all contract TAB work shall be repeated after engineering and construction have been evaluated and re-submitted for approval at no additional cost to the owner.

D. Do not proceed with the remaining systems until intermediate report is approved by the COR.

3.7 TAB PROCEDURES

A. TAB shall be performed in accordance with the requirement of the Standard under which TAB agency is certified by either AABC, TABB or NEBB. Balancing shall be done proportionally to all applicable systems.
   1. At least one trunk damper shall be 100% open.
   2. At least one branch damper shall be 100%open per trunk.
   3. At least one terminal device duct be 100% open per branch.

B. General: During TAB all related system components shall be in full operation. Fan and pump rotation, motor loads and equipment vibration shall be checked and corrected as necessary before proceeding with TAB. Set controls and/or block off parts of distribution systems to simulate design operation of variable volume air or water systems for test and balance work.

C. Allow 15 days time in construction schedule for TAB and submission of all reports for an organized and timely correction of deficiencies.

D. Air Balance and Equipment Test: Include air handling units, fans, terminal units, fan coil units, room diffusers/outlets/inlets, computer room AC units, and laboratory fume hoods and biological safety cabinets.
   1. Artificially load air filters by partial blanking to produce static air pressure drop of manufacturer’s recommended pressure drop.
   2. Adjust fan speeds to provide design air flow. V-belt drives, including fixed pitch pulley requirements, are specified in Section 23 05 11, COMMON WORK RESULTS FOR HVAC Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANTS and STEAM GENERATION.

3. Test and balance systems in all specified modes of operation, including variable volume, economizer, and fire emergency modes. Verify that dampers and other HVAC controls function properly.
4. Variable air volume (VAV) systems:
   a. Coordinate TAB, including system volumetric controls, with Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.
   b. Section 23 36 00, AIR TERMINAL UNITS, specifies that maximum and minimum flow rates for air terminal units (ATU) be factory set. Check and readjust ATU flow rates if necessary to meet design criteria. Balance air distribution from ATU on full cooling maximum scheduled cubic meters per minute (cubic feet per minute). Reset room thermostats and check ATU 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 ATU is in the maximum heating mode. 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 al operating conditions).
   c. Adjust operating pressure control setpoint to maintain the design flow to each space with the lowest setpoint.
5. Record final measurements for air handling equipment performance data sheets.

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

and reheat coils. Make air and water temperature measurements at the same time.

3.8 VIBRATION TESTING

A. Furnish instruments and perform vibration measurements as specified in Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT. Field vibration balancing is specified in Section 23 05 11, COMMON WORK RESULTS FOR HVAC, Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANTS and STEAM GENERATION. 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 all rooms. The COR may designate the specific rooms to be tested.

B. Take measurements with a calibrated sound level meter and octave band analyzer of the accuracy required by AABC, TABB or NEBB.

C. Sound reference levels, formulas and coefficients shall be according to 2019 ASHRAE Handbook, "HVAC Applications", Chapter 49, SOUND AND VIBRATION CONTROL.

D. Determine compliance with specifications as follows:
   1. When sound pressure levels are specified, including the NC Criteria in Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT:
      a. Reduce the background noise as much as possible by shutting off unrelated audible equipment.
      b. Measure octave band sound pressure levels with specified equipment "off."

c. Measure octave band sound pressure levels with specified equipment "on."

d. Use the DIFFERENCE in corresponding readings to determine the sound pressure due to equipment.

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 level due to equipment plus the distance factor. Use 16 meters (50 feet) for sound level location.

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

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

3.10 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.

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.

- - E N D - - -

SECTION 23 07 11
HVAC AND BOILER PLANT INSULATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. Field applied insulation for thermal efficiency and condensation control for

1. HVAC piping, ductwork and equipment.
2. Boiler plant mechanical systems including burner fuel oil storage and handling facilities but excluding outside steam distribution.
3. Re-insulation of HVAC piping, ductwork and equipment, and boiler plant piping, breeching and stacks and equipment after asbestos abatement.

B. Definitions

1. ASJ: All service jacket, white finish facing or jacket.
2. Air conditioned space: Space having air temperature and/or humidity controlled by mechanical equipment.
3. Cold: Equipment, ductwork or piping handling media at design temperature of 16 degrees C (60 degrees F) or below.
4. Concealed: Ductwork and piping above ceilings and in chases, interstitial space and pipe spaces.
5. Exposed: Piping, ductwork, and equipment exposed to view in finished areas including mechanical, Boiler Plant and electrical equipment rooms or exposed to outdoor weather. Attics and crawl spaces where air handling units are located are considered to be mechanical rooms. Shafts, chases unfinished attics, crawl spaces and pipe basements are not considered finished areas.
6. FSK: Foil-scrim-kraft facing.
7. Hot: HVAC Ductwork handling air at design temperature above 16 degrees C (60 degrees F);HVAC equipment or piping handling media above 41 degrees C (105 degrees F); Boiler Plant breechings and stack temperature range 150-370 degrees C(300-700 degrees F) and piping media and equipment 32 to 230 degrees C(90 to 450 degrees F).
8. Density: kg/m^3 - kilograms per cubic meter (Pcf - pounds per cubic foot).

9. Runouts: Branch pipe connections up to 25-mm (one-inch) nominal size to fan coil units or reheat coils for terminal units.
10. Thermal conductance: Heat flow rate through materials.
    a. Flat surface: Watt per square meter (BTU per hour per square foot).
    b. Pipe or Cylinder: Watt per square meter (BTU per hour per linear foot).
11. Thermal Conductivity (k): Watt per meter, per degree C (BTU per inch thickness, per hour, per square foot, per degree F temperature difference).
12. Vapor Retarder (Vapor Barrier): A material which retards the transmission (migration) of water vapor. Performance of the vapor retarder is rated in terms of permeance (perms). For the purpose of this specification, vapor retarders shall have a maximum published permeance of 0.1 perms and vapor barriers shall have a maximum published permeance of 0.001 perms.
13. HPS: High pressure steam (415 kPa [60 psig] and above).
14. HPR: High pressure steam condensate return.
15. MPS: Medium pressure steam (110 kPa [16 psig] thru 414 kPa [59 psig].
16. MPR: Medium pressure steam condensate return.
17. LPS: Low pressure steam (103 kPa [15 psig] and below).
18. LPR: Low pressure steam condensate gravity return.
19. PC: Pumped condensate.
20. HWHS: Hot water heating supply.
21. HWHR: Hot water heating return.
22. GH: Hot glycol-water heating supply.
23. GHR: Hot glycol-water heating return.
24. FWPD: Feedwater pump discharge.
25. FWPS: Feedwater pump suction.
26. CTPD: Condensate transfer pump discharge.
27. CTPS: Condensate transfer pump suction.
28. VR: Vacuum condensate return.
29. CPD: Condensate pump discharge.
30. R: Pump recirculation.
31. FOS: Fuel oil supply.

32. FOR: Fuel oil return.
33. CW: Cold water.
34. SW: Soft water.
35. HW: Hot water.
36. CH: Chilled water supply.
37. CHR: Chilled water return.
38. GC: Chilled glycol-water supply.
39. GCR: Chilled glycol-water return.
40. RS: Refrigerant suction.
41. PVDC: Polyvinylidene chloride vapor retarder jacketing, white.

1.2 RELATED WORK

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

B. Section 02 82 11, TRADITIONAL ASBESTOS ABATEMENT.

C. Section 07 84 00, FIRESTOPPING.

D. Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT and STEAM GENERATION.

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

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

G. Section 23 22 23, STEAM CONDENSATE PUMPS

H. Section 23 50 11, BOILER PLANT MECHANICAL EQUIPMENT

I. Section 23 51 00, BREECHINGS, CHIMNEYS, and STACKS

1.3 QUALITY ASSURANCE

A. Refer to article QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC and Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT and STEAM GENERATION.

B. Criteria:

1. Comply with NFPA 90A, particularly paragraphs 4.3.3.1 through 4.3.3.6, 4.3.10.2.6, and 5.4.6.4, parts of which are quoted as follows:

   4.3.3.1 Pipe insulation and coverings, duct coverings, duct linings, vapor retarder facings, adhesives, fasteners, tapes, and supplementary materials added to air ducts, plenums, panels, and duct silencers used in duct systems, unless otherwise provided for in 4.3.3.1.1 or 4.3.3.1.2., shall have, in the form in which they are used, a maximum flame spread index of 25 without evidence of continued progressive combustion and a maximum smoke developed index of 50 when tested in accordance with NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials*.

4.3.3.1.1 Where these products are to be applied with adhesives, they shall be tested with such adhesives applied, or the adhesives used shall have a maximum flame spread index of 25 and a maximum smoke developed index of 50 when in the final dry state. *(See 4.2.4.2.)*

4.3.3.1.2 The flame spread and smoke developed index requirements of 4.3.3.1.1 shall not apply to air duct weatherproof coverings where they are located entirely outside of a building, do not penetrate a wall or roof, and do not create an exposure hazard.

4.3.3.2 Closure systems for use with rigid and flexible air ducts tested in accordance with UL 181, Standard for Safety Factory-Made Air Ducts and Air Connectors, shall have been tested, listed, and used in accordance with the conditions of their listings, in accordance with one of the following:

(1) UL 181A, Standard for Safety Closure Systems for Use with Rigid Air Ducts and Air Connectors

(2) UL 181B, Standard for Safety Closure Systems for Use with Flexible Air Ducts and Air Connectors

4.3.3.3 Air duct, panel, and plenum coverings and linings, and pipe insulation and coverings shall not flame, glow, smolder, or smoke when tested in accordance with a similar test for pipe covering, ASTM C 411, Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation, at the temperature to which they are exposed in service.

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

4.3.3.4 Air duct coverings shall not extend through walls or floors that are required to be fire stopped or required to have a fire resistance rating, unless such coverings meet the requirements of 5.4.6.4.

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

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

4.3.10.2.6 Materials exposed to the airflow shall be noncombustible or limited combustible and have a maximum smoke developed index of 50 or comply with the following.

4.3.10.2.6.1 Electrical wires and cables and optical fiber cables shall be listed as noncombustible or limited combustible and have a maximum smoke developed index of 50 or shall be listed as having a maximum peak optical density of 0.5 or less, an average optical density of 0.15 or less, and a maximum flame spread distance of 1.5 m (5 ft) or less when tested in accordance with NFPA 262, Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.

4.3.10.2.6.4 Optical-fiber and communication raceways shall be listed as having a maximum peak optical density of 0.5 or less, an average optical density of 0.15 or less, and a maximum flame spread distance of 1.5 m (5 ft) or less when tested in accordance with UL 2024, Standard for Safety Optical-Fiber Cable Raceway.

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

5.4.6.4 Where air ducts pass through walls, floors, or partitions that are required to have a fire resistance rating and where fire dampers are not required, the opening in the construction around the air duct shall be as follows:

(1) Not exceeding a 25.4 mm (1 in.) average clearance on all sides

(2) Filled solid with an approved material capable of preventing the passage of flame and hot gases sufficient to ignite cotton waste when subjected to the time-temperature fire conditions required for fire barrier penetration as specified in NFPA 251, *Standard Methods of Tests of Fire Endurance of Building Construction and Materials*

2. Test methods: ASTM E84, UL 723, or NFPA 255.
3. Specified k factors are at 24 degrees C (75 degrees F) mean temperature unless stated otherwise. Where optional thermal insulation material is used, select thickness to provide thermal conductance no greater than that for the specified material. For pipe, use insulation manufacturer's published heat flow tables. For domestic hot water supply and return, run out insulation and condensation control insulation, no thickness adjustment need be made.
4. All materials shall be compatible and suitable for service temperature and shall not contribute to corrosion or otherwise attack surface to which applied in either the wet or dry state.

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

1.4 SUBMITTALS

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

B. Shop Drawings:

1. All information, clearly presented, shall be included to determine compliance with drawings and specifications and ASTM, federal and military specifications.

a. Insulation materials: Specify each type used and state surface burning characteristics.
b. Insulation facings and jackets: Each type used. Make it clear that white finish will be furnished for exposed ductwork, casings and equipment.
c. Insulation accessory materials: Each type used.
d. Manufacturer's installation and fitting fabrication instructions for flexible unicellular insulation.
e. Make reference to applicable specification paragraph numbers for coordination.

C. Samples:
1. Each type of insulation: Minimum size 100 mm (4 inches) square for board/block/ blanket; 150 mm (6 inches) long, full diameter for round types.
2. Each type of facing and jacket: Minimum size 100 mm (4 inches square).
3. Each accessory material: Minimum 120 ML (4 ounce) liquid container or 120 gram (4 ounce) dry weight for adhesives / cement / mastic.

1.5 STORAGE AND HANDLING OF MATERIAL

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

1.6 APPLICABLE PUBLICATIONS

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

B. Federal Specifications (Fed. Spec.):
L-P-535E (2)- 1999......Plastic Sheet (Sheeting): Plastic Strip; Poly (Vinyl Chloride) and Poly (Vinyl Chloride - Vinyl Acetate), Rigid.

C. Military Specifications (Mil. Spec.):
MIL-A-3316C -1987 Adhesives, Fire-Resistant, Thermal Insulation
MIL-A-24179A (1)-2016 Adhesive, Flexible Unicellular-Plastic Thermal Insulation

MIL-C-19565C (1)- 2016 Coating Compounds, Thermal Insulation, Fire-and Water-Resistant, Vapor-Barrier

MIL-C-20079H-1987 ......Cloth, Glass; Tape, Textile Glass; and Thread, Glass and Wire-Reinforced Glass

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

A167-99 2014...........Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip

B209-2014...............Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate

C411-2019...............Standard test method for Hot-Surface Performance of High-Temperature Thermal Insulation

C449-2019...............Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement

C533-2017...............Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation

C534-2017...............Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form

C547-2017...............Standard Specification for Mineral Fiber pipe Insulation

C552-07 ....Standard Specification for Cellular Glass Thermal Insulation

C553-2015...............Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications

C585-2016...............Standard Practice for Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System) R (1998)

C612-2014...............Standard Specification for Mineral Fiber Block and Board Thermal Insulation

C1126- 2019............Standard Specification for Faced or Unfaced Rigid Cellular Phenolic Thermal Insulation

C1136- 2017.............Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation

D1668-97a 2017 ....Standard Specification for Glass Fabrics (Woven and Treated) for Roofing and Waterproofing

E84-2014................Standard Test Method for Surface Burning Characteristics of Building Materials

E119-2007...............Standard Test Method for Fire Tests of Building Construction and Materials

E136-2019...............Standard Test Methods for Behavior of Materials in a Vertical Tube Furnace at 750 degrees C (1380 F)

E. National Fire Protection Association (NFPA):

90A-2018................Standard for the Installation of Air Conditioning and Ventilating Systems

96-2018.................Standard~~s~~ for Ventilation Control and Fire Protection of Commercial Cooking Operations

101-2018................Life Safety Code

251-2014 ....Standard methods of Tests of Fire Endurance of Building Construction Materials

255-2006................Standard Method of tests of Surface Burning Characteristics of Building Materials

F. Underwriters Laboratories, Inc (UL):

723-2018................UL Standard for Safety Test for Surface Burning Characteristics of Building Materials with Revision of 09/08

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

SP58-2018...............Pipe Hangers and Supports Materials, Design, and Manufacture

PART 2 - PRODUCTS

2.1 MINERAL FIBER OR FIBER GLASS

A. ASTM C612 (Board, Block), Class 1 or 2, density 48 kg/m^3 (3 pcf), k = 0.037 (0.26) at 24 degrees C (75 degrees F), external insulation for temperatures up to 204 degrees C (400 degrees F) with foil scrim (FSK) facing.

B. ASTM C553 (Blanket, Flexible) Type I, Class B-5, Density 32 kg/m^3 (2 pcf), k = 0.04 (0.27) at 24 degrees C (75 degrees F), for use at temperatures up to 204 degrees C (400 degrees F) with foil scrim (FSK) facing.

C. ASTM C547 (Pipe Fitting Insulation and Preformed Pipe Insulation), Class 1, k = 0.037 (0.26) at 24 degrees C (75 degrees F), for use at temperatures up to 230 degrees C (450 degrees F) with an all service vapor retarder jacket with polyvinyl chloride premolded fitting covering.

2.2 MINERAL WOOL OR REFRACTORY FIBER

A. Comply with Standard ASTM C612, Class 3, 450 degrees C (850 degrees F).

2.3 RIGID CELLULAR PHENOLIC FOAM

A. Preformed (molded) pipe insulation, ASTM C1126, type III, grade 1, k = 0.021(0.15) at 10 degrees C (50 degrees F), for use at temperatures up to 121 degrees C (250 degrees F) with all service vapor retarder jacket with polyvinyl chloride premolded fitting covering.

B. Equipment and Duct Insulation, ASTM C 1126, type II, grade 1, k = 0.021 (0.15) at 10 degrees C (50 degrees F), for use at temperatures up to 121 degrees C (250 degrees F) with rigid cellular phenolic insulation and covering, and all service vapor retarder jacket.

2.4 CELLULAR GLASS CLOSED-CELL

A. Comply with Standard ASTM C177, C518, density 120 kg/m^3 (7.5 pcf) nominal, k = 0.033 (0.29) at 24~~0~~ degrees C (75 degrees F).

B. Pipe insulation for use at temperatures up to 200 degrees C (400 degrees F) with all service vapor retarder jacket.

2.5 FLEXIBLE ELASTOMERIC CELLULAR THERMAL

A. ASTM C177, C518, k = 0.039 (0.27) at 24 degrees C (75 degrees F), flame spread not over 25, smoke developed not over 50, for temperatures from minus 4 degrees C (40 degrees F) to 93 degrees C (200 degrees F). No jacket required.

2.6 CALCIUM SILICATE

A. Preformed pipe Insulation: ASTM C533, Type I and Type II with indicator denoting asbestos-free material.

B. Premolded Pipe Fitting Insulation: ASTM C533, Type I and Type II with indicator denoting asbestos-free material.
C. Equipment Insulation: ASTM C533, Type I and Type II
D. Characteristics:

Insulation Characteristics		
ITEMS	**TYPE I**	**TYPE II**
Temperature, maximum degrees C (degrees F)	649 (1200)	927 (1700)
Density (dry), Kg/m^3 (lb/ ft3)	232 (14.5)	288 (18)
Thermal conductivity: Min W/ m K (Btu in/h ft^2 degrees F)@ mean temperature of 93 degrees C (200 degrees F)	0.059 (0.41)	0.078 (0.540)
Surface burning characteristics: Flame spread Index, Maximum	0	0
Smoke Density index, Maximum	0	0

2.7 INSULATION FACINGS AND JACKETS

A. Vapor Retarder, higher strength with low water permeance = 0.02 or less perm rating, Beach puncture 50 units for insulation facing on exposed ductwork, casings and equipment, and for pipe insulation jackets. Facings and jackets shall be all service type (ASJ) or PVDC Vapor Retarder jacketing.
B. ASJ jacket shall be white kraft bonded to 0.025 mm (1 mil) thick aluminum foil, fiberglass reinforced, with pressure sensitive adhesive closure. Comply with ASTM C1136. Beach puncture 50 units, Suitable for painting without sizing. Jackets shall have minimum 40 mm (1-1/2 inch) lap on longitudinal joints and minimum 75 mm (3 inch) butt strip on end joints. Butt strip material shall be same as the jacket. Lap and butt strips shall be self-sealing type with factory-applied pressure sensitive adhesive.
C. Vapor Retarder medium strength with low water vapor permeance of 0.02 or less perm rating), Beach puncture 25 units: Foil-Scrim-Kraft (FSK)

or PVDC vapor retarder jacketing type for concealed ductwork and equipment.

D. Field applied vapor barrier jackets shall be provided, in addition to the specified facings and jackets, on all exterior piping and ductwork as well as on interior piping and ductwork exposed to outdoor air (i.e., in ventilated attics, piping in ventilated (not air conditioned) spaces, etc.) in high humidity areas conveying fluids below ambient temperature. The vapor barrier jacket shall consist of a multi-layer laminated cladding with a maximum water vapor permeance of 0.001 perms. The minimum puncture resistance shall be 35 cm-kg (30 inch-pounds) for interior locations and 92 cm-kg (80 inch-pounds) for exterior or exposed locations or where the insulation is subject to damage.

E. Glass Cloth Jackets: Presized, minimum 0.18 kg per square meter (7.8 ounces per square yard), 2000 kPa (300 psig) bursting strength with integral vapor retarder where required or specified. Weather proof if utilized for outside service.

F. Factory composite materials may be used provided that they have been tested and certified by the manufacturer.

G. Pipe fitting insulation covering (jackets): Fitting covering shall be premolded to match shape of fitting and shall be polyvinyl chloride (PVC) conforming to Fed Spec L-P-335, composition A, Type II Grade GU, and Type III, minimum thickness 0.7 mm (0.03 inches). Provide color matching vapor retarder pressure sensitive tape.

H. Aluminum Jacket-Piping systems and circular breeching and stacks: ASTM B209, 3003 alloy, H-14 temper, 0.6 mm (0.023 inch) minimum thickness with locking longitudinal joints. Jackets for elbows, tees and other fittings shall be factory-fabricated to match shape of fitting and of 0.6 mm (0.024) inch minimum thickness aluminum. Fittings shall be of same construction as straight run jackets but need not be of the same alloy. Factory-fabricated stainless steel bands shall be installed on all circumferential joints. Bands shall be 13 mm (0.5 inch) wide on 450 mm (18 inch) centers. System shall be weatherproof if utilized for outside service.

2.8 REMOVABLE INSULATION JACKETS

A. Insulation and Jacket:

1. Non-Asbestos Glass mat, type E needled fiber.

2. Temperature maximum of 450°F, Maximum water vapor transmission of 0.00 perm, and maximum moisture absorption of 0.2 percent by volume.
3. Jacket Material: Silicon/fiberglass and LFP 2109 pure PTFE.
4. Construction: One piece jacket body with three-ply braided pure Teflon or Kevlar thread and insulation sewn as part of jacket. Belt fastened.

2.9 PIPE COVERING PROTECTION SADDLES

A. Cold pipe support: Premolded pipe insulation 180 degrees (half-shells) on bottom half of pipe at supports. Material shall be cellular glass or high density Polyisocyanurate insulation of the same thickness as adjacent insulation. Density of Polyisocyanurate insulation shall be a minimum of 48 kg/m^3 (3.0 pcf).

Nominal Pipe Size and Accessories Material (Insert Blocks)	
Nominal Pipe Size mm (inches)	Insert Blocks mm (inches)
Up through 125 (5)	150 (6) long
150 (6)	150 (6) long
200 (8), 250 (10), 300 (12)	225 (9) long
350 (14), 400 (16)	300 (12) long
450 through 600 (18 through 24)	350 (14) long

B. Warm or hot pipe supports: Premolded pipe insulation (180 degree half-shells) on bottom half of pipe at supports. Material shall be high density Polyisocyanurate (for temperatures up to 149 degrees C [300 degrees F]), cellular glass or calcium silicate. Insulation at supports shall have same thickness as adjacent insulation. Density of Polyisocyanurate insulation shall be a minimum of 48 kg/m^3 (3.0 pcf).

C. Boiler Plant Pipe supports: MSS SP58, Type 39. Apply at all pipe support points, except where MSS SP58, Type 3 pipe clamps provided as part of the support system.

2.10 ADHESIVE, MASTIC, CEMENT

A. Mil. Spec. MIL-A-3316, Class 1: Jacket and lap adhesive and protective finish coating for insulation.

B. Mil. Spec. MIL-A-3316, Class 2: Adhesive for laps and for adhering insulation to metal surfaces.

C. Mil. Spec. MIL-A-24179, Type II Class 1: Adhesive for installing flexible unicellular insulation and for laps and general use.

D. Mil. Spec. MIL-C-19565, Type I: Protective finish for outdoor use.

E. Mil. Spec. MIL-C-19565, Type I or Type II: Vapor barrier compound for indoor use.

F. ASTM C449: Mineral fiber hydraulic-setting thermal insulating and finishing cement.

G. Other: Insulation manufacturers' published recommendations.

2.11 MECHANICAL FASTENERS

A. Pins, anchors: Welded pins, or metal or nylon anchors with galvanized steel-coated or fiber washer, or clips. Pin diameter shall be as recommended by the insulation manufacturer.

B. Staples: Outward clinching monel or galvanized steel.

C. Wire: 1.3 mm thick (18 gage) soft annealed galvanized or 1.9 mm (14 gage) copper clad steel or nickel copper alloy.

D. Bands: 13 mm (0.5 inch) nominal width, brass, galvanized steel, aluminum or stainless steel.

2.12 REINFORCEMENT AND FINISHES

A. Glass fabric, open weave: ASTM D1668, Type III (resin treated) and Type I (asphalt treated).

B. Glass fiber fitting tape: Mil. Spec MIL-C-20079, Type II, Class 1.

C. Tape for Flexible Elastomeric Cellular Insulation: As recommended by the insulation manufacturer.

D. Hexagonal wire netting: 25 mm (one inch) mesh, 0.85 mm thick (22 gage) galvanized steel.

E. Corner beads: 50 mm (2 inch) by 50 mm (2 inch), 0.55 mm thick (26 gage) galvanized steel; or, 25 mm (1 inch) by 25 mm (1 inch), 0.47 mm thick (28 gage) aluminum angle adhered to 50 mm (2 inch) by 50 mm (2 inch) Kraft paper.

F. PVC fitting cover: Fed. Spec L-P-535, Composition A, 11-86 Type II, Grade GU, with Form B Mineral Fiber insert, for media temperature 4 degrees C (40 degrees F) to 121 degrees C (250 degrees F). Below 4 degrees C (40 degrees F) and above 121 degrees C (250 degrees F). Provide double layer insert. Provide color matching vapor barrier pressure sensitive tape.

2.13 FIRESTOPPING MATERIAL

A. Other than pipe and duct insulation, refer to Section 07 84 00 FIRESTOPPING.

2.14 FLAME AND SMOKE

A. Unless shown otherwise all assembled systems shall meet flame spread 25 and smoke developed 50 rating as developed under ASTM, NFPA and UL standards and specifications. See paragraph 1.3 "Quality Assurance".

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

A. Required pressure tests of duct and piping joints and connections shall be completed and the work approved by the COR for application of insulation. Surface shall be clean and dry with all foreign materials, such as dirt, oil, loose scale and rust removed.

B. Except for specific exceptions, insulate entire specified equipment, piping (pipe, fittings, valves, accessories), and duct systems. Insulate each pipe and duct individually. Do not use scrap pieces of insulation where a full length section will fit.

C. Where removal of insulation of piping, ductwork and equipment is required to comply with Section 02 82 11, TRADITIONAL ASBESTOS ABATEMENT and Section 02 82 13.13, GLOVEBAG ASBESTOS ABATEMENT, such areas shall be reinsulated to comply with this specification.

D. Insulation materials shall be installed in a first class manner with smooth and even surfaces, with jackets and facings drawn tight and smoothly cemented down at all laps. Insulation shall be continuous through all sleeves and openings, except at fire dampers and duct heaters (NFPA 90A). Vapor retarders shall be continuous and uninterrupted throughout systems with operating temperature 16 degrees C (60 degrees F) and below. Lap and seal vapor retarder over ends and exposed edges of insulation. Anchors, supports and other metal projections through insulation on cold surfaces shall be insulated and vapor sealed for a minimum length of 150 mm (6 inches).

E. Install vapor stops at all insulation terminations on either side of valves, pumps and equipment and particularly in straight lengths of pipe insulation.

F. Construct insulation on parts of equipment such as chilled water pumps and heads of chillers, convertors and heat exchangers that must be opened periodically for maintenance or repair, so insulation can be removed and replaced without damage. Install insulation with bolted 1 mm thick (20 gage) galvanized steel or aluminum covers as complete units, or in sections, with all necessary supports, and split to coincide with flange/split of the equipment.

G. Insulation on hot piping and equipment shall be terminated square at items not to be insulated, access openings and nameplates. Cover all exposed raw insulation with white sealer or jacket material.

H. Protect all insulations outside of buildings with aluminum jacket using lock joint or other approved system for a continuous weather tight system. Access doors and other items requiring maintenance or access shall be removable and sealable.

I. Insulate PRVs, flow meters, and steam traps.

J. HVAC work not to be insulated:

1. Internally insulated ductwork and air handling units.
2. Relief air ducts (Economizer cycle exhaust air).
3. Exhaust air ducts and plenums, and ventilation exhaust air shafts.
4. Equipment: Expansion tanks, flash tanks, hot water pumps, steam condensate pumps.
5. In hot piping: Unions, flexible connectors, control valves, PRVs, safety valves and discharge vent piping, vacuum breakers, thermostatic vent valves, steam traps 20 mm (3/4 inch) and smaller, exposed piping through floor for convectors and radiators. Insulate piping to within approximately 75 mm (3 inches) of uninsulated items.

K. Boiler plant work not to be insulated (NI)or if insulated the insulation shall be removal jacket type (RJ):

1. Pipes, valves and fittings:
    a. Gas fuel(NI)
    b. Oil unheated (NI)
    c. Compressed Air (NI)
    d. Flowmeter sensing piping and blowdown (NI)
    e. Level sensor piping and blowdown (NI)
    f. Tank drains (NI)
    g. Vents-tank, safety and back pressure valves except protective. (NI)

h. Continuous blowdown and boiler water sampling except protective. (NI)
i. Threaded valves (RJ)
j. Check valves (RJ)
k. Unions (RJ)
l. Orifice flanges (RJ)
m. Dielectric flanges and unions (RJ)
n. Steam header drains (NI)
o. Non-return stop and check valve drains (NI)
p. Pneumatic controls (NI)
q. Pressure transmission to gages (NI)
r. Piping in control panels (NI)
s. Tube cleaning piping (NI)
t. Chemical feed from pump-type feeders (NI)
u. Condensate piping from flash tank to condensate return pump (NI)

2. Boilers:
a. Water column, piping and blowdown (NI)
b. Auxiliary low water cutoff, piping and blowdown(NI)
c. Remote water level indicators and piping blowdown(NI)
d. Steam gage piping(NI)
e. Soot blower and piping(NI)
f. Safety valves and drip pan ells(NI)
g. Water level sensors and piping except where required by equipment manufacturer(NI)
h. Control piping and devices or interlocks(NI)
i. Drum heads (watertube boilers) (NI)

3. Equipment:
a. Condensate return pump units(NI)
b. Vacuum return pump units(NI)
c. Pumps-inlet to outlet(NI)
d. Flash tanks(NI)
e. Safety valves(NI)
f. Water meters(NI)
g. Oil meters(NI)
h. Air compressors and tanks(NI)
i. Refrigerated or desiccant air drier(NI)

j. Chemical feeders(NI)
k. Boiler and feedwater sampler(NI)
l. All nameplates (NI)

4. Specialties:
   a. Pressure reducing valves(RJ)
   b. Control valves-water and steam(NI)
   c. Level sensors-piping, valves and blowdown(NI)
   d. Back pressure regulators-oil and steam(NI)
   e. Strainers under 65 mm (2-1/2 inch) pipe size(RJ)
   f. Expansion bellows(RJ)
   g. Flexible connectors(RJ)
   h. Ball joints except piping between joints(NI)

L. Apply insulation materials subject to the manufacturer's recommended temperature limits. Apply adhesives, mastic and coatings at the manufacturer's recommended minimum coverage.

M. Elbows, flanges and other fittings shall be insulated with the same material as is used on the pipe straights. The elbow/ fitting insulation shall be field-fabricated, mitered or factory prefabricated to the necessary size and shape to fit on the elbow/ fitting. Use of polyurethane spray-foam to fill a PVC elbow jacket is prohibited on cold applications.

N. Firestop Pipe and Duct insulation:
   1. Provide firestopping insulation at fire and smoke barriers through penetrations. Fire stopping insulation shall be UL listed as defines in Section 07 84 00, FIRESTOPPING.
   2. Pipe and duct penetrations requiring fire stop insulation including, but not limited to the following:
      a. Pipe risers through floors
      b. Pipe or duct chase walls and floors
      c. Smoke partitions
      d. Fire partitions

O. Freeze protection of above grade outdoor piping (over heat tracing tape): 26 mm (10 inch) thick insulation, for all pipe sizes 75 mm(3 inches) and smaller and 25 mm(1inch) thick insulation for larger pipes. Provide metal jackets for all pipes. Provide for cold water make-up to cooling towers and condenser water piping and chilled water piping as described in Section 23 21 13, HYDRONIC PIPING (electrical heat tracing systems).

P. Provide vapor barrier jackets over insulation as follows:
   1. All piping and ductwork exposed to outdoor weather.
   2. All interior piping and ducts conveying fluids exposed to outdoor air (i.e., in attics, ventilated (not air conditioned) spaces, etc.) below ambient air temperature.

Q. Provide metal jackets over insulation as follows:
   1. All piping and ducts exposed to outdoor weather.
   2. Piping exposed in building, within 1800 mm (6 feet) of the floor, that connects to sterilizers, kitchen and laundry equipment. Jackets may be applied with pop rivets. Provide aluminum angle ring escutcheons at wall, ceiling or floor penetrations.
   3. A 50 mm (2 inch) overlap is required at longitudinal and circumferential joints.

3.2 INSULATION INSTALLATION

A. Mineral Fiber Board:
   1. Faced board: Apply board on pins spaced not more than 300 mm (12 inches) on center each way, and not less than 75 mm (3 inches) from each edge of board. In addition to pins, apply insulation bonding adhesive to entire underside of horizontal metal surfaces. Butt insulation edges tightly and seal all joints with laps and butt strips. After applying speed clips cut pins off flush and apply vapor seal patches over clips.
   2. Plain board:
      a. Insulation shall be scored, beveled or mitered to provide tight joints and be secured to equipment with bands spaced 225 mm (9 inches) on center for irregular surfaces or with pins and clips on flat surfaces. Use corner beads to protect edges of insulation.
      b. For hot equipment: Stretch 25 mm (1 inch) mesh wire, with edges wire laced together, over insulation and finish with insulating and finishing cement applied in one coat, 6 mm (1/4 inch) thick, trowel led to a smooth finish.

3. Exposed, unlined ductwork and equipment in unfinished areas, mechanical and electrical equipment rooms and attics, interstitial spaces and duct work exposed to outdoor weather:
   a. 50 mm (2 inch) thick insulation faced with ASJ (white all service jacket): Supply air duct.
   b. 50 mm (2 inch) thick insulation faced with ASJ: Return air duct, mixed air plenums and prefilter housing.
   c. Outside air intake ducts: 25 mm (one inch) thick insulation faced with ASJ.
   d. Exposed, unlined supply and return ductwork exposed to outdoor weather: 50 mm (2 inch) thick insulation faced with a reinforcing membrane and two coats of vapor barrier mastic or multi-layer vapor barrier with a maximum water vapor permeability of 0.001 perms.
4. Cold equipment: 40 mm (1-1/2inch) thick insulation faced with ASJ.
   a. Water filter, chemical feeder pot or tank.
   b. Pneumatic, cold storage water and surge tanks.
5. Hot equipment: 40 mm (1-1/2 inch) thick insulation faced with ASJ.
   a. Convertors, air separators, steam condensate pump receivers.
   b. Reheat coil casing and separation chambers on steam humidifiers located above ceilings.
   c. Domestic water heaters and hot water storage tanks (not factory insulated).
   d. Booster water heaters for dietetics dish and pot washers and for washdown grease-extracting hoods.
6. Laundry: Hot exhaust ducts from dryers and from ironers, where duct is exposed in the laundry.

B. Flexible Mineral Fiber Blanket:
   1. Adhere insulation to metal with 75 mm (3 inch) wide strips of insulation bonding adhesive at 200 mm (8 inches) on center all around duct. Additionally secure insulation to bottom of ducts exceeding 600 mm (24 inches) in width with pins welded or adhered on 450 mm (18 inch) centers. Secure washers on pins. Butt insulation edges and seal joints with laps and butt strips. Staples may be used to assist in securing insulation. Seal all vapor retarder

penetrations with mastic. Sagging duct insulation will not be acceptable. Install firestop duct insulation where required.

2. Supply air ductwork to be insulated includes main and branch ducts from AHU discharge to room supply outlets, and the bodies of ceiling outlets to prevent condensation. Insulate sound attenuator units, coil casings and damper frames. To prevent condensation, insulate trapeze type supports and angle iron hangers for flat oval ducts that are in direct contact with metal duct.
3. Concealed supply air ductwork.
   a. Above ceilings at a roof level, in attics, and duct work exposed to outdoor weather: 50 mm (2 inch) thick insulation faced with FSK.
   b. Above ceilings for other than roof level: 40 mm (1 ½ inch) thick insulation faced with FSK.
4. Concealed return air duct:
   a. Above ceilings at a roof level, unconditioned areas, and in chases with external wall or containing steam piping; 40 mm (1-1/2 inch) thick, insulation faced with FSK.
   b. Concealed return air ductwork in other locations need not be insulated.
5. Concealed outside air duct: 40 mm (1-1/2 inch) thick insulation faced with FSK.
6. Exhaust air branch duct from autopsy refrigerator to main duct: 40 mm (1-1/2 inch) thick insulation faced with FSK.

C. Molded Mineral Fiber Pipe and Tubing Covering:
   1. Fit insulation to pipe or duct, aligning longitudinal joints. Seal longitudinal joint laps and circumferential butt strips by rubbing hard with a nylon sealing tool to assure a positive seal. Staples may be used to assist in securing insulation. Seal all vapor retarder penetrations on cold piping with a generous application of vapor barrier mastic. Provide inserts and install with metal insulation shields at outside pipe supports. Install freeze protection insulation over heating cable.
   2. Contractor's options for fitting, flange and valve insulation:

a. Insulating and finishing cement for sizes less than 100 mm (4 inches) operating at surface temperature of 16 degrees C (61 degrees F) or more.
b. Factory premolded, one piece PVC covers with mineral fiber, (Form B), inserts. Provide two insert layers for pipe temperatures below 4 degrees C (40 degrees F), or above 121 degrees C (250 degrees F). Secure first layer of insulation with twine. Seal seam edges with vapor barrier mastic and secure with fitting tape.
c. Factory molded, ASTM C547 or field mitered sections, joined with adhesive or wired in place. For hot piping finish with a smoothing coat of finishing cement. For cold fittings, 16 degrees C (60 degrees F) or less, vapor seal with a layer of glass fitting tape imbedded between two 2 mm (1/16 inch) coats of vapor barrier mastic.
d. Fitting tape shall extend over the adjacent pipe insulation and overlap on itself at least 50 mm (2 inches).

3. Nominal thickness in millimeters and inches specified in the schedule at the end of this section.

D. Rigid Cellular Phenolic Foam:

1. Rigid closed cell phenolic insulation may be provided for piping, ductwork and equipment for temperatures up to 121 degrees C (250 degrees F).
2. Note the NFPA 90A burning characteristics requirements of 25/50 in paragraph 1.3.B
3. Provide secure attachment facilities such as welding pins.
4. Apply insulation with joints tightly drawn together
5. Apply adhesives, coverings, neatly finished at fittings, and valves.
6. Final installation shall be smooth, tight, neatly finished at all edges.
7. Minimum thickness in millimeters (inches) specified in the schedule at the end of this section.
8. Exposed, unlined supply and return ductwork exposed to outdoor weather: 50 mm (2 inch) thick insulation faced with a multi-layer vapor barrier with a maximum water vapor permeance of 0.00 perms.
9. Condensation control insulation: Minimum 25 mm (1.0 inch) thick for all pipe sizes.

a. HVAC: Cooling coil condensation piping to waste piping fixture or drain inlet. Omit insulation on plastic piping in mechanical rooms.

E. Cellular Glass Insulation:

1. Pipe and tubing, covering nominal thickness in millimeters and inches as specified in the schedule at the end of this section.
2. Underground Piping Other than or in lieu of that Specified in Section 23 21 13, HYDRONIC PIPING and Section 33 63 00, STEAM ENERGY DISTRIBUTION: Type II, factory jacketed with a 3 mm laminate jacketing consisting of 3000 mm x 3000 mm (10 ft x 10 ft) asphalt impregnated glass fabric, bituminous mastic and outside protective plastic film.
   a. 75 mm (3 inches) thick for hot water piping.
   b. As scheduled at the end of this section for chilled water piping.
   c. Underground piping: Apply insulation with joints tightly butted. Seal longitudinal self-sealing lap. Use field fabricated or factory made fittings. Seal butt joints and fitting with jacketing as recommended by the insulation manufacturer. Use 100 mm (4 inch) wide strips to seal butt joints.
   d. Provide expansion chambers for pipe loops, anchors and wall penetrations as recommended by the insulation manufacturer.
   e. Underground insulation shall be inspected and approved by the COR as follows:
      1) Insulation in place before coating.
      2) After coating.
   f. Sand bed and backfill: Minimum 75 mm (3 inches) all around insulated pipe or tank, applied after coating has dried.
3. Cold equipment: 50 mm (2 inch) thick insulation faced with ASJ for chilled water pumps, water filters, chemical feeder pots or tanks, expansion tanks, air separators and air purgers.
4. Exposed, unlined supply and return ductwork exposed to outdoor weather: 50 mm (2 inch) thick insulation faced with a reinforcing membrane and two coats of vapor barrier mastic or multi-layer vapor barrier with a water vapor permeability of 0.00 perms.

F. Polyisocyanurate Closed-Cell Rigid Insulation:

1. Polyisocyanurate closed-cell rigid insulation (PIR) may be provided for exterior piping, equipment and ductwork for temperature up to 149 degree C (300-degree F).
2. Install insulation, vapor barrier and jacketing per manufacturer's recommendations. Particular attention should be paid to recommendations for joint staggering, adhesive application, external hanger design, expansion/contraction joint design and spacing and vapor barrier integrity.
3. Install insulation with all joints tightly butted (except expansion) joints in hot applications).
4. If insulation thickness exceeds 63 mm (2.5 inches), install as a double layer system with longitudinal (lap) and butt joint staggering as recommended by manufacturer.
5. For cold applications, vapor barrier shall be installed in a continuous manner. No staples, rivets, screws or any other attachment device capable of penetrating the vapor barrier shall be used to attach the vapor barrier or jacketing. No wire ties capable of penetrating the vapor barrier shall be used to hold the insulation in place. Banding shall be used to attach PVC or metal jacketing.
6. Elbows, flanges and other fittings shall be insulated with the same material as is used on the pipe straights. The elbow/ fitting insulation shall be field-fabricated, mitered or factory prefabricated to the necessary size and shape to fit on the elbow/ fitting. Use of polyurethane spray-foam to fill PVC elbow jacket is prohibited on cold applications.
7. For cold applications, the vapor barrier on elbows/fittings shall be either mastic-fabric-mastic or 2 mil thick PVDC vapor barrier adhesive tape.
8. All PVC and metal jacketing shall be installed so as to naturally shed water. Joints shall point down and shall be sealed with either adhesive or caulking (except for periodic slip joints).
9. Underground piping: Follow instructions for above ground piping but the vapor retarder jacketing shall be 6 mil thick PVDC or minimum 30 mil thick rubberized bituminous membrane. Sand bed and backfill shall be a minimum of 150 mm (6 inches) all around insulated pipe.

10. Exposed, unlined supply and return ductwork exposed to outdoor weather: 50 mm (2 inch) thick insulation faced with a multi-layer vapor barrier with a water vapor permeance of 0.00 perms.
11. Note the NFPA 90A burning characteristic requirements of 25/50 in paragraph 1.3B. Refer to paragraph 3.1 for items not to be insulated.
12. Minimum thickness in millimeter (inches) specified in the schedule at the end of this section.

G. Flexible Elastomeric Cellular Thermal Insulation:

1. Apply insulation and fabricate fittings in accordance with the manufacturer's installation instructions and finish with two coats of weather resistant finish as recommended by the insulation manufacturer.
2. Pipe and tubing insulation:
   a. Use proper size material. Do not stretch or strain insulation.
   b. To avoid undue compression of insulation, provide cork stoppers or wood inserts at supports as recommended by the insulation manufacturer. Insulation shields are specified under Section 23 05 11, COMMON WORK RESULTS FOR HVAC and Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT and STEAM GENERATION.
   c. Where possible, slip insulation over the pipe or tubing prior to connection, and seal the butt joints with adhesive. Where the slip-on technique is not possible, slit the insulation and apply it to the pipe sealing the seam and joints with contact adhesive. Optional tape sealing, as recommended by the manufacturer, may be employed. Make changes from mineral fiber insulation in a straight run of pipe, not at a fitting. Seal joint with tape.
3. Apply sheet insulation to flat or large curved surfaces with 100 percent adhesive coverage. For fittings and large pipe, apply adhesive to seams only.
4. Pipe insulation: nominal thickness in millimeters (inches as specified in the schedule at the end of this section.
5. Minimum 20 mm (0.75 inch) thick insulation for pneumatic control lines for a minimum distance of 6 m (20 feet) from discharge side of the refrigerated dryer.
6. Use Class S (Sheet), 20 mm (3/4 inch) thick for the following:

a. Chilled water pumps
b. Bottom and sides of metal basins for winterized cooling towers (where basin water is heated).
c. Chillers, insulate any cold chiller surfaces subject to condensation which has not been factory insulated.
d. Piping inside refrigerators and freezers: Provide heat tape under insulation.

7. Exposed, unlined supply and return ductwork exposed to outdoor weather: 50 mm (2 inch) thick insulation faced with a multi-layer vapor barrier with a water vapor permeance of 0.00 perms.

H. Calcium Silicate:

1. Minimum thickness in millimeter (inches) specified in the schedule at the end of this section for piping other than in boiler plant. See paragraphs 3.3 through 3.7 for Boiler Plant Applications.
2. Engine Exhaust Insulation for Emergency Generator and Diesel Driven Fire Pump: Type II, Class D, 65 mm (2 1/2 inch) nominal thickness. Cover exhaust completely from engine through roof or wall construction, including muffler. Secure with 16 AWG galvanized annealed wire or 0.38 x 12 mm 0.015 x 1/2 IN wide galvanized bands on 300 mm 12 IN maximum centers. Anchor wire and bands to welded pins, clips or angles. Apply 25 mm 1 IN hex galvanized wire over insulation. Fill voids with 6 mm 1/4 IN insulating cement.

3.3 APPLICATION – BOILER PLANT, PIPE, VALVES, STRAINERS AND FITTINGS

A. Temperature range 120 to 230 degrees C (251 to 450 degrees F);

1. Application; Steam service 110 kpa (16 psig nominal) and higher, high pressure condensate to trap assembly, boiler bottom blowoff from boiler to blowoff valve closest to boiler.
2. Insulation and Jacket:
   a. Calcium silicate for piping from zero to 1800 mm (6 feet) above boiler room floor, feedwater heater mezzanine floor or access platform and any floors or platforms on which tanks or pumps are located.
   b. Mineral fiber for remaining locations.
   c. ASJ with PVC premolded fitting coverings.
   d. Aluminum jacket from zero to 1800 mm (6 feet) above floor on atomizing steam and condensate lines at boilers and burners.

3. Thickness:

Nominal Thickness Of Calcium Silicate Insulation (Boiler Plant)	
Pipe Diameter mm (in)	Insulation Thickness mm (in)
25 (1 and below)	125 (5)
25 to 38 (1-1/4 to 1-1/2)	125 (5)
38 (1-1/2) and above	150 (6)

B. Temperature range 100 to 121 degrees C (211 to 250 degrees F):

1. Application: Steam service 103 kpa (15 psig) and below, trap assembly discharge piping, boiler feedwater from feedwater heater to boiler feed pump recirculation, feedwater heater overflow, heated oil from oil heater to burners.
2. Insulation and Jacket:
   a. Calcium silicate for piping from zero to 1800 mm (0 to 6 feet) above boiler room floor, feedwater heater mezzanine floor and access platform, and any floors or access platforms on which tanks or pumps are located.
   b. Mineral Fiber or rigid closed cell phenolic foam for remaining locations.
   c. ASJ with PVC premolded fitting coverings.
   d. Aluminum jacket from zero to 1800 mm (6 feet) above floor on condensate lines at boilers and burners.
3. Thickness-calcium silicate and mineral fiber insulation:

Nominal Thickness Of Insulation	
Pipe Diameter mm (in)	Insulation Thickness mm (in)
25 (1 and below)	50 (2)
25 to 38 (1-1/4 to 1-1/2)	50 (2)
38 (1-1/2) and above	75 (3)

4. Thickness-rigid closed-cell phenolic foam insulation:

Nominal Thickness Of Insulation	
Pipe Diameter mm (in)	Insulation Thickness mm (in)
25 (1 and below)	38 (1.5)
25 to 38 (1-1/4 to 1-1/2)	38 (1.5)
38 (1-1/2) and above	75(3)

C. Temperature range 32 to 99 degrees C (90 to 211 degrees F):

1. Application: Pumped condensate, vacuum heating return, gravity and pumped heating returns, condensate transfer, condensate transfer pump recirculation, heated oil system to heaters and returns from burners, condensate return from convertors and heated water storage tanks.
2. Insulation Jacket:
   a. Calcium silicate for piping from zero to 1800 mm (six feet above boiler room floor, feedwater heater mezzanine floor and access platform and any floor or access platform on which tanks or pumps are located.
   b. Mineral fiber or rigid closed-cell phenolic foam for remaining locations.
   c. ASJ with PVC premolded fitting coverings.
3. Thickness-calcium silicate and mineral fiber insulation:

Nominal Thickness Of Insulation	
Pipe Diameter mm (in)	Insulation Thickness mm (in)
25 (1 and below)	38 (1.5)
25 to 38 (1-1/4 to 1-1/2)	50(2)
38 (1-1/2) and above	75 (3)

4. Thickness-rigid closed-cell phenolic foam insulation:

Nominal Thickness Of Insulation	
Pipe Diameter mm (in)	Insulation Thickness mm (in)
25 (1 and below)	19 (0.75)
25 to 38 (1-1/4 to 1-1/2)	19 (0.75)
38 (1-1/2) and above	25 (1)

D. Protective insulation to prevent personnel injury:
   1. Application: Piping from zero to 1800 mm (6 feet) above all floors and access platforms including continuous blowoff, feedwater and boiler water sample, blowoff tank vent, flash tank vents and condensate tank vent, shot-type chemical feed, fire tube boiler bottom blowoff after valves, valve by-passes.
   2. Insulation thickness: 25 mm (1 inch).
   3. Insulation and jacket: Calcium silicate with ASJ except provide aluminum jacket on piping at boilers within 1800 mm (6 feet) of floor. Use PVC premolded fitting coverings when all service jacket is utilized.

E. Installation:
   1. At pipe supports, weld pipe covering protection saddles to pipe, except where MS-SP58, type 3 pipe clamps are utilized.
   2. Insulation shall be firmly applied, joints butted tightly, mechanically fastened by stainless steel wires on 300 mm (12 inch) centers.
   3. At support points, fill and thoroughly pack space between pipe covering protective saddle bearing area.
   4. Terminate insulation and jacket hard and tight at anchor points.
   5. Terminate insulation at piping facilities not insulated with a 45 degree chamfered section of insulating and finishing cement covered with jacket.
   6. On calcium silicate, mineral fiber and rigid closed-cell phenolic foam systems, insulated flanged fittings, strainers and valves with sections of pipe insulation cut, fitted and arranged neatly and firmly wired in place. Fill all cracks, voids and coat outer surface with insulating cement. Install jacket. Provide similar construction on welded and threaded fittings on calcium silicate systems or use premolded fitting insulation.

7. On mineral fiber systems, insulate welded and threaded fittings more than 50 mm (2 inches) in diameter with compressed blanket insulation (minimum 2/1) and finish with jacket or PVC cover.
8. Insulate fittings 50 mm (2 inches) and smaller with mastic finishing material and cover with jacket.
9. Insulate valve bonnet up to valve side of bonnet flange to permit bonnet flange removal without disturbing insulation.
10. Install jacket smooth, tight and neatly finish all edges. Over wrap ASJ butt strips by 50 percent. Secure aluminum jacket with stainless steel bands 300 mm (12 inches) on center or aluminum screws on 200 mm (4 inch) centers.
11. Do not insulate basket removal flanges on strainers.

3.4 APPLICATION-BOILER FLUE GAS SYSTEMS

A. Temperature range 150 to 370 degrees C (300 to 700 degrees F):
   1. Application: Transitions, stacks and breechings from boiler outlet to stack outlet; induced draft fans (if provided); flue gas recirculation fans and ductwork (if provided).
   2. Thickness:
      a. Single-wall duct systems: 50 mm (2 inches).
      b. Double-wall factory-fabricated duct systems with air space between walls: None.
   3. Insulation and jacket: Calcium Silicate with aluminum sheet metal jacket.

B. Protective Insulation to Prevent Personnel Injury:
   1. Application: Double wall factory-fabricated duct system with uninsulated air space between walls within 900 mm (3 feet) horizontally and 1800 mm (6 feet) vertically of platform or floor.
   2. Insulation thickness; 25 mm (1 inch).
   3. Insulation and jacket: Calcium Silicate with aluminum sheet metal jacket.

C. Insulating:
   1. Provide attachment facilities such as angles, welded studs, clip angles.
   2. Apply insulation with joints tightly butted and staggered. Seal joints with high temperature cement.
   3. Provide metal corner beads.

4. Band insulation firmly in place to provide a smooth surface. Maximum band spacing shall not be more than 300 mm (12 inches).
5. Install jacket. All surfaces outside of building must be weather tight. At termination of stub stacks, provide metal closure system which is connected and sealed to perimeter of stack to prevent water penetration of insulation.

3.5 APPLICATION-BOILER DEAERATING FEEDWATER HEATER, TANKS

A. Temperature range 38 to 120 degrees C (100 to 250 degrees F)
   1. Application: Deaerating feedwater heater and storage tank, condensate storage tanks, heat exchangers, blowoff tank.
   2. Insulation Thickness:
      a. Feedwater heater and storage tanks: 75 mm (3 inches)
      b. Condensate storage tanks: 50 mm (2 inches)
      c. Blowoff tank, heat exchangers: 25 mm (1 inch).
   3. Insulation and covering: Calcium silicate with glass cloth jacket.

B. Insulating:
   1. Insulate tanks with an assembly of chamfered block to fit curvature. Secure with 1.6 mm diameter (16 gage) wire or stainless steel bands 300 mm (12 inches) on centers, fill all voids and interstices with finishing cement coat, imbed hexagonal wire mesh in first finish coat. Provide a second finish coat and a glass cloth covering.
   2. Apply glass cloth with adhesive, smooth, tight and neatly finished at all cloth edges; prime to receive paint.
   3. Do not insulate over nameplates and data plates. Nameplates and data plates must be legible.

3.6 APPLICATION ON HEATED OR TRACED OIL FACILITIES OUTSIDE OF BUILDING

A. Temperature range 30 to 120 degrees C (85 to 250 degrees F).
   1. Application: Aboveground oil storage tank, oil and steam or hot water underground and aboveground piping systems.
   2. Insulation thickness:
      a. Tanks; 38 mm (1-1/2 inches) plus finish.
      b. Oil suction and return piping: 38 mm (1-1/2 inches plus finish).
      c. Steam or hot water piping: 38 mm (1-1/2 inches) plus finish.

B. Insulation and jacket (aboveground tanks and piping): Calcium silicate with glass cloth or aluminum jacket, weatherproof jacket when used outside of building.

C. Insulation and Jacket (underground piping); Calcium silicate with fiberglass scrim jacket located within secondary containment. Allow space for heating cable (if provided) along bottom line of piping.

3.7 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of section 23 08 00 – COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the 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.

3.8 PIPE INSULATION SCHEDULE

A. Provide insulation for piping systems as scheduled below:

Insulation Wall Thickness Millimeters (Inches)					
		Nominal Pipe Size Millimeters (Inches)			
Operating Temperature Range/Service	Insulation Material	Less than 25 (1)	25 – 32 (1 – 1¼)	38 – 75 (1½ - 3)	100 (4) and Above
	Insulation Wall Thickness Millimeters (Inches)				
122-177 degrees C (251-350 degrees F) (HPS, MPS)	Mineral Fiber (Above ground piping only)	75 (3)	100 (4)	113 (4.5)	113 (4.5)
93-260 degrees C (200-500 degrees F) (HPS, HPR)	Calcium Silicate	100 (4)	125 (5)	150 (6)	150 (6)
100-121 degrees C (212-250 degrees F) (HPR, MPR, LPS, vent piping from PRV Safety Valves, Condensate receivers and flash tanks)	Mineral Fiber (Above ground piping only)	62 (2.5)	62 (2.5)	75 (3.0)	75 (3.0)
100-121 degrees C (212-250 degrees F) (HPR, MPR, LPS, vent piping from PRV Safety Valves,	Rigid Cellular Phenolic Foam	50 (2.0)	50 (2.0)	75 (3.0)	75 (3.0)

Condensate receivers and flash tanks)					
38-94 degrees C (100-200 degrees F) (LPR, PC, HWH, HWHR, GH and GHR)	Mineral Fiber (Above ground piping only)	38 (1.5)	38 (1.5)	50 (2.0)	50 (2.0)
38-99 degrees C (100-211 degrees F) (LPR, PC, HWH, HWHR, GH and GHR)	Rigid Cellular Phenolic Foam	38 (1.5)	38 (1.5)	50 (2.0)	50 (2.0)
39-99 degrees C (100-211 degrees F) (LPR, PC, HWH, HWHR, GH and GHR)	Polyiso-cyanurate Closed-Cell Rigid (Exterior Locations only)	38 (1.5)	38 (1.5)	----	----
38-94 degrees C (100-200 degrees F) (LPR, PC, HWH, HWHR, GH and GHR)	Flexible Elastomeric Cellular Thermal (Above ground piping only)	38 (1.5)	38 (1.5)	----	----
4-16 degrees C (40-60 degrees F) (CH, CHR, GC, GCR and RS for DX refrigeration)	Rigid Cellular Phenolic Foam	38 (1.5)	38 (1.5)	38 (1.5)	38 (1.5)
4-16 degrees C (40-60 degrees F) (CH and CHR within chiller room and pipe chase and underground)	Cellular Glass Closed-Cell	50 (2.0)	50 (2.0)	75 (3.0)	75 (3.0)
4-16 degrees C (40-60 degrees F) (CH, CHR, GC, GCR and RS for DX refrigeration)	Cellular Glass Closed-Cell	38 (1.5)	38 (1.5)	38 (1.5)	38 (1.5)
4-16 degrees C (40-60 degrees F) (CH, CHR, GC and GCR (where underground)	Polyiso-cyanurate Closed-Cell Rigid	38 (1.5)	38 (1.5)	50 (2.0)	50 (2.0)

4-16 degrees C (40-60 degrees F) (CH, CHR, GC, GCR and RS for DX refrigeration)	Polyiso-cyanurate Closed-Cell Rigid (Exterior Locations only)	38 (1.5)	38 (1.5)	38 (1.5)	38 (1.5)
(40-60 degrees F) (CH, CHR, GC, GCR and RS for DX refrigeration)	Flexible Elastomeric Cellular Thermal (Above ground piping only)	38 (1.5)	38 (1.5)	38 (1.5)	38 (1.5)

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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 REQUIRMENTS. A Commissioning Agent (CxA) appointed by the VA will manage the commissioning process.

1.2 RELATED WORK

A. Section 01 00 00 GENERAL REQUIREMENTS.

B. Section 01 33 00 SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

C. Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS.

D. Section 23 05 41 NOISE AND VIBRATION CONTROL for HVAC PIPING AND EQUIPMENT.

E. Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC.

F. Section 23 09 11 Instrumentation and Controls for Boiler Plant.

G. Section 23 09 23 DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

1.3 SUMMARY

A. This Section includes requirements for commissioning the HVAC systems of the related subsystems and equipment. This Section supplements the general requirements specified in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS.

B. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for more details regarding processes and procedures as well as roles and responsibilities for all Commissioning Team members.

1.4 DEFINITIONS

A. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for definitions.

1.5 COMMISSIONED SYSTEMS

A. Commissioning of a system or systems specified in Division 23 is part of the construction process. Documentation and testing of these systems, as well as training of the VA’s Operation and Maintenance personnel in accordance with the requirements of Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS and of Division 23, is required in cooperation with the VA and the Commissioning Agent.

B. The Facility HVAC systems commissioning will include the systems listed in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS.

1.6 SUBMITTALS

A. The commissioning process requires review of selected Submittals that pertain to the systems to be commissioned. The Commissioning Agent will provide a list of submittals that will be reviewed by the Commissioning Agent. This list will be reviewed and approved by the VA prior to forwarding to the Contractor. Refer to Section 01 33 23 SHOP DRAWINGS, PRODUCT DATA, and SAMPLES for further details.

B. The commissioning process requires Submittal review simultaneously with engineering review. Specific submittal requirements related to the commissioning process are specified in Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS.

1.7 APPLICABLE PUBLICATIONS

A. The following publications form a part of this specification to the extent indicated by the reference thereto. In text the publications are referenced to by the acronym of the organization.

B. Department of Veterans Affairs (VA):

PG 18-10 2007...........Mission Critical Facilities - DRAFT

PG 18-10 2007...........Life-Safety Protected Facilities - DRAFT

C. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE):

HANDBOOK 2019...........HVAC Applications ASHRAE Handbook, Chapter 39, Testing, Adjusting, and Balancing, Chapter 44, HVAC Commissioning and Chapter 49, Sound and Vibration Control

HANDBOOK 2017...........HVAC Fundamentals ASHRAE Handbook, Chapter 8, Sound and Vibration

D. Associated Air Balance Council (AABC):

7th Edition 2016........AABC National Standards for Total System Balance

E. National Environmental Balancing Bureau (NEBB):

9th Edition 2019........Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems

3rd Edition 2015 ....Procedural Standards for the Measurement of Sound and Vibration

2rd Edition 2019 ... Standard for Whole Building Technical Commissioning of New Construction

F. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):

006 2006................HVAC Duct Construction Standard – Metal and Flexible Duct

3rd Edition 2005 ... HVAC Systems Testing, Adjusting and Balancing

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 CONSTRUCTION INSPECTIONS

A. Commissioning of HVAC systems will require inspection of individual elements of the HVAC systems construction throughout the construction period. The Contractor shall coordinate with the Commissioning Agent in accordance with Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS and the Commissioning plan to schedule HVAC systems inspections as required to support the Commissioning Process.

3.2 PRE-FUNCTIONAL CHECKLISTS

A. The Contractor shall complete Pre-Functional Checklists to verify systems, subsystems, and equipment installation is complete and systems are ready for Systems Functional Performance Testing. The Commissioning Agent will prepare Pre-Functional Checklists to be used to document equipment installation. Refer to Sections 23 05 41 NOISE AND VIBRATION CONTROL for HVAC PIPING AND EQUIPMENT, Section 23 05 93 TESTING, ADJUSTING, AND BALANCING FOR HVAC and Section 23 09 23 DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC requirements. The Contractor shall complete the checklists. Completed checklists shall be submitted to the VA and to the Commissioning Agent for review. The Commissioning Agent may spot check a sample of completed checklists. If the Commissioning Agent determines that the information provided on the checklist is not accurate, the Commissioning Agent will return the marked-up checklist to the Contractor for correction and resubmission. If the Commissioning Agent determines that a significant number of completed checklists for similar equipment are not accurate, the Commissioning Agent will select a broader sample of checklists for review. If the Commissioning Agent determines that a significant number of the broader sample of checklists is also inaccurate, all the checklists for the type of equipment will be returned to the Contractor for correction and resubmission. Refer to SECTION 01 91 00 GENERAL COMMISSIONING REQUIREMENTS for submittal requirements for Pre-Functional Checklists, Equipment Startup Reports, and other commissioning documents.

3.3 CONTRACTORS TESTS

A. Contractor tests as required by other sections of Division 23 shall be scheduled and documented in accordance with Section 01 00 00 GENERAL REQUIREMENTS. All testing shall be incorporated into the project schedule. Contractor shall provide no less than 7 calendar days' notice of testing. The Commissioning Agent will witness selected Contractor tests at the sole discretion of the Commissioning Agent. Contractor tests shall be completed prior to scheduling Systems Functional Performance Testing.

3.4 SYSTEMS FUNCTIONAL PERFORMANCE TESTING:

A. The Commissioning Process includes Systems Functional Performance Testing that is intended to test systems functional performance under steady state conditions, to test system reaction to changes in operating conditions, and system performance under emergency conditions. The Commissioning Agent will prepare detailed Systems Functional Performance Test procedures for review and approval by the COR. The Contractor shall review and comment on the tests prior to approval. The Contractor shall provide the required labor, materials, and calibrated test equipment identified in the test procedure to perform the tests. The Commissioning Agent will witness and document the testing. The Contractor shall sign the test reports to verify tests were performed. See Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS, for additional requirements.

3.5 TRAINING OF VA PERSONNEL

A. Training of the VA operation and maintenance personnel is required in cooperation with the COR and Commissioning Agent. Provide competent, factory authorized personnel to provide instruction to operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. Contractor shall submit training agendas and trainer resumes in accordance with the requirements of Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS. The instruction shall be scheduled in coordination with the VA COR after submission and approval of formal training plans. Refer to Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS and Division 23 Sections for additional Contractor training requirements.

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SECTION 23 08 11
DEMONSTRATIONS AND TESTS FOR BOILER PLANT

PART 1 - GENERAL

1.1 DESCRIPTION

A. Procedures for onsite demonstration and testing of equipment and systems, including temporary facilities.

B. Instruction of Government operating personnel.

C. All demonstrations, instructions, access platforms, and testing must be completed prior to Government acceptance for beneficial use. All safety devices shall pass 100 percent before the boiler plant can be accepted for beneficial use.

D. Plumbing and emergency power systems are not included.

E. Definitions:

1. Start-Up: Initial inspection, cleaning, lubrication, adjustment, and operation of equipment and systems by the contractor with the assistance of the representatives of the equipment manufacturers.
2. Pre-Tests: The final stage of the start-up procedure. This occurs after all adjustments have been made except for minor fine-tuning that can be done during the pre-test. Serves as verification that the systems are ready for the final test. Witnessing of pre-test by COR is not required.
3. Final Tests: Tests, witnessed by the COR or designated representative, which demonstrate that all equipment and systems are in compliance with requirements. At VA expense, VA may utilize the services of an independent testing organization or consultant to witness the tests. If any portion of the final test fail and must be retested the Government shall receive a full credit for any expenses incurred for services from independent testing organizations or consultant services for all re-inspections or tests.

F. A complete listing of common acronyms and abbreviations are included in Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

D. Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION.
E. Section 23 05 51, NOISE AND VIBRATION CONTROL FOR BOILER PLANT.
F. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
G. Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.
H. Section 23 10 00, FACILITY FUEL SYSTEMS.
I. Section 23 21 11, BOILER PLANT PIPING SYSTEMS.
J. Section 23 50 11, BOILER PLANT MECHANICAL EQUIPMENT.
K. Section 23 52 39, FIRE-TUBE BOILERS.

1.3 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Where conflicts occur these specifications and the VHA standard will govern.

B. Department of Veterans Affairs (VA):

2008....................VHA Boiler Plant Safety Devices Testing Manual, Fifth Edition

PG-18-10-2015...........Physical Security and Resiliency Design Manual

1.4 SUBMITTALS

A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 23 08 11, DEMONSTRATIONS AND TESTS FOR BOILER PLANT", with applicable paragraph identification.

C. Names and qualifications of personnel performing demonstrations, instructions and tests.

D. Certification that pre-testing is complete. Copies of boiler-burner and feedwater deaerator pre-test data as specified. Copies of the VHA Boiler Plant Safety Devices Testing Manual completely filled out with notes.

E. Preliminary schedule of all demonstrations, instructions and final tests two weeks prior to proposed dates.

F. Provide reports within three weeks after satisfactory completion of demonstrations, instructions, and tests. List date, type of work, persons participating, amount of time, test results, calculations of test results, test data.

G. 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.

H. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

1.5 QUALITY ASSURANCE

A. Experienced, trained technical service personnel who are representatives of the equipment manufacturers and system designers shall demonstrate, provide instructions, pre-test and final test, as specified, the following equipment:
   1. Boilers and economizers
   2. Burners
   3. Control systems
   4. Instrumentation
   5. Deaerating feedwater heater

B. Experienced technicians shall demonstrate and provide instructions on the following equipment:
   1. Pumps and piping systems
   2. Ventilation and heating systems
   3. Compressed air systems
   4. Control and safety valves

C. The person responsible for programming the computer workstation shall demonstrate and provide instructions on hardware, software and programming.

D. The COR, upon request, will provide a list of personnel to receive instructions and will coordinate their attendance at agreed upon times.

E. All safety devices shall comply with the VHA Boiler Plant Safety Devices Testing Manual.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 PREPARATION FOR FINAL TESTS, DEMONSTRATIONS, AND INSTRUCTIONS

A. Verify that equipment and systems are fully operational. Complete all start-up and pre-test activities for all equipment and systems. Complete all construction and finish work.

B. Arrange for all test personnel for all equipment to be continuously present during one period of time so that all equipment and systems can be tested in their interrelated functions. For instance, feedwater deaerator will be tested during the boiler testing, and instrumentation performance will be evaluated in conjunction with boiler testing.

C. Deliver maintenance and operating manuals four weeks prior to instruction period.
D. Furnish all special tools.

3.2 FINAL TESTS

A. Demonstrate proper operation of each equipment and system to include demonstration and testing of all safety devices.
B. Provide tests on equipment as specified in the individual specification sections.

3.3 START-UP AND TESTING

A. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.
B. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contactor testing schedules with the COR and Commissioning Agent. Provide a minimum notice of 10 working days prior to startup and testing.

3.4 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
B. Components provided under this section of the specification will be tested as part of a larger system.

3.5 DEMONSTRATIONS AND TRAINING

A. Demonstrate operation and maintenance of equipment and systems to Government personnel no more than four weeks prior to scheduled Government operation of the plant.
B. Use operation and maintenance manuals, as-built drawings, and single line drawings as basis of instruction. Review contents of manuals and drawings with personnel in detail to explain all aspects of operation and maintenance.
C. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shut-down of each item of equipment. Allow Government personnel to practice operating the equipment under supervision of instructors.
    1. All demonstrations shall follow a contractor provided written step by step standard operating procedure.

2. Demonstrate lockout/tagout locations for all equipment and hazards using a written procedure that clearly identifies lockout points (breakers, disconnects, valves, etc.) for each piece of equipment. Valves are to be identified by a valve tag number, breakers are by number located in breaker box number, disconnect location and number etc.
3. Demonstrate the as-built drawings are correct and provide single line drawings for each system.

D. Prepare and insert additional data in operations and maintenance manuals when need for additional data becomes apparent during instructions.

E. Provide services of manufacturer’s technical representative to instruct VA personnel in operation and maintenance of units.

F. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

3.6 TIME ALLOCATED FOR DEMONSTRATIONS AND INSTRUCTIONS

A. At least 16 total instructor hours to include boilers, economizers, burners, burner controls, combustion controls, instrumentation.

B. At least 8 total instructor hours to include computer workstation and programs.

C. At least 8/ total instructor hours to include pumps, steam turbine, feedwater deaerator, and other equipment.

D. Do not exceed three trainees per session, one four-hour session, per day, per trainee.

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SECTION 23 09 11
INSTRUMENTATION AND CONTROL FOR BOILER PLANT

PART 1 - GENERAL

1.1 DESCRIPTION

A. Automatic controls, instruments, monitoring and data management systems and accessories for the boilers, burners and other boiler plant mechanical equipment. The specification classifies the systems into automatic boiler and burner control systems, burner management systems (flame safeguard), and data management and instrumentation systems.

B. A complete listing of common acronyms and abbreviations are included in Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

D. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTUAL COMPONENTS.

E. Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION.

F. Section 23 05 51, NOISE AND VIBRATION CONTROL FOR BOILER PLANT.

G. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

H. Section 23 08 11, DEMONSTRATIONS AND TESTS FOR BOILER PLANT.

I. Section 23 10 00, FACILITY FUEL SYSTEMS.

J. Section 23 21 11, BOILER PLANT PIPING SYSTEMS.

K. Section 23 50 11, BOILER PLANT MECHANICAL EQUIPMENT.

L. Section 23 51 00, BREECHINGS, CHIMNEYS, AND STACKS.

M. Section 23 52 39, FIRE-TUBE BOILERS.

N. Section 26 05 11, REQUIREMENTS for ELECTRICAL INSTALLATIONS.

O. Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES.

P. Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS.

Q. Section 26 27 26, WIRING DEVICES.

R. 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. Where conflicts occur these specifications and the VHA standard will govern.

B. American National Standards Institute (ANSI):

INCITS 154-S2019........Office Machines and Supplies – Alphanumeric Machines – Keyboard Arrangement

C. American Society of Mechanical Engineers (ASME):

B31.1-2014..............Power Piping

B40.100-2013............Pressure Gauges and Gauge Attachments

PTC 4-2013..............Fired Steam Generators

D. National Electrical Manufacturers Association (NEMA):

ICS 6-1993(R2006) Industrial Control and Systems: Enclosures

WC63.2-1996(R2003)......Performance Standard for Coaxial Premise Data Communications Cables

E. National Fire Protection Association (NFPA):

70-2017.................National Electrical Code

85-2019.................Boiler and Combustion Systems Hazards Code

F. Underwriters Laboratories Inc. (UL):

508-1999(R2018).........Standard for Industrial Control Equipment

1449-2014(R2019)........Standard for Surge Protective Devices

1998-2013...............Standard for Software in Programmable Components

G. Department of Veterans Affairs (VA)

2018....................VHA Boiler Plant Safety Devices Testing Manual, Fifth Edition

1.4 SUBMITTALS

A. Submittals shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT", 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. Certificates of compliance with paragraph, QUALITY ASSURANCE of this section (subparagraphs 1.5.A, B, D & F). In addition, submit Past Performance Questionnaire (form attached) for five (5) past projects of the same class (scope & complexity) as this project.
E. Submit information sufficient to verify compliance with all contract requirements as specified and shown on project drawings.
F. Automatic Boiler Control and Burner Management and Safety Interlock Systems:
   1. Catalog cuts and specification sheets providing description and performance data on: Controllers, control and indicating stations, sensors and transmitters, signal conditioners, electric switches and relays, indicators and annunciators, safety interlock devices, drive units and actuators, control valves, mechanical linkage systems, compressed air filters and regulators.
   2. Statement from controller manufacturer that the type and model submitted is the current generation and that the manufacturer will support the units with parts and service for at least ten years, and that the equipment submitted meets all VA specifications.
   3. Information on all the specific systems that is sufficient to allow complete troubleshooting. As a minimum, this should include explanation of the control logic, and wiring diagrams of equipment and systems to include locations and wire numbers of all safety device test points that will be required to complete safety device testing in accordance with VA requirements, and sequence of operation of all components of the system.
   4. Hardware systems schematics showing field and panel equipment interface block diagram.
   5. Location of interlock devices on the burners, boilers, fuel trains and accessory equipment, all safety devices shall be easily accessible for testing...
G. Boiler Plant Instrumentation:
   1. Catalog cuts and specification sheets providing description and performance data on instruments and accessories.

2. Installation and troubleshooting instructions for all equipment in bound sets shipped with equipment.
3. List of ranges of recorder displays. Paper chart recorders are prohibited.
4. Flow meter primary element design, size, performance, and sizing calculation. Steam flow performance data for flow meters verifying project performance requirements.
5. Complete wiring and piping diagrams for all equipment and systems.
6. Wiring and piping materials.

H. Instrumentation and Control Panels:
1. Drawing showing arrangement of instruments and controls on panels.
2. Drawing showing panel arrangements, construction, door swing clearance allowance, dimensions, finishes.
3. Description of panel construction.
4. Seismic restraint design data for freestanding instrument or control panels. Refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

I. Computer Workstation and Programming:
1. Hardware specifications.
2. Software model number and supplier. Include complete documentation on all software with shipment.
3. Confirmation that graphics to be provided complies with the specification.
4. Description of computer furniture.

J. As-built Logic and Wiring Diagrams: One set of reproducible prints and CAD disks delivered to COR prior to turning systems over to VA for operation. Supply revised drawings if changes are made during the startup and commissioning process.

K. Fluid Flow Meters:
1. Catalog cuts and drawings with description, specifications and dimensions of meters and accessories.
2. Design and construction of meters and accessories.
3. Performance data including flow, pressure drop, accuracy over the metering range of the actual fluids to be metered.
4. Pressure and temperature limitations.
5. Manufacturer's installation instructions.

6. Arrangement of register face and remote indicator (if provided).

L. Pressure Gauges and Thermometers:
   1. Catalog cuts showing design, construction, dimensions of gauges and accessories.
   2. Accuracy.
   3. Pressure and temperature limitations of gauges and accessories.
   4. List of scale ranges to be provided.

M. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replacement parts, and troubleshooting guide:
   1. Include complete list indicating all components of the systems.
   2. Include complete diagrams of the internal wiring for each item of equipment.
   3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

N. Completed System Readiness Checklist provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician, and dated on the date of completion, in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

O. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

1.5 QUALITY ASSURANCE

A. The boiler and burner control, monitoring, data gathering, instrumentation and associated systems specified in this section shall be provided by one company that has been in business at least three years engineering, designing and servicing industrial and institutional boiler control and instrumentation systems similar to those specified herein, as a primary business. That company shall furnish all components and provide complete calibration, programming, start-up, testing, demonstrations, instructions and training services.

B. Submit documented evidence, including start-up and acceptance test data, and references, that the company has performed satisfactory work on at least six systems similar to those specified, list any VA boiler plant projects completed in the past. For instance, submit experience information on systems involving parallel positioning combustion control and on variable speed forced draft fan drives, if these systems are specified. Submit in writing that all specifications were read and fully understood.

C. If new burners are part of the contract, the burner manufacturer shall be responsible for the burner management system (flame safeguard), including interlocks, all accessories and for coordination with other control and monitoring systems.
D. Equipment Experience Requirements: Refer to Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION.
E. Code Approval:
   1. All burner management and combustion control systems and devices shall comply with NFPA 85, regardless of boiler type or size. Locations and arrangements of safety devices on fuel trains shall comply with diagrams included in “Annex A” in the code, as modified by the VA standard details and the VHA Boiler Plant Safety Devices Testing Manual requirements.
   2. All burner management controls and interlock devices shall be UL listed and FM approved. All controllers that include burner management functions shall be UL listed and FM approved.
   3. Parallel positioning combustion control systems shall comply with UL 1998.
   4. Computer-based electronic equipment shall conform to the requirements of FCC Part 15, Subpart J, for Class A computing devices governing radio frequency electromagnetic interference (EMI) while continuing to operate normally.
   5. All electrical wiring shall be in accordance with NFPA 70.
   6. The use of wire nuts is prohibited. All wire connections must be made at terminal blocks and terminal strips.
   7. The use of liquid tight or other flexible conduit systems is limited to 900 mm (3 foot) in length unless longer runs are required for door swings or other equipment access.
   8. All wire runs are required to be in conduit.
F. Personnel: All work shall be done by properly trained, skilled technicians who are regularly employed and qualified in the installation, programming, start-up, calibration, and testing of the systems provided, and who will be directed by experienced engineers employed by the equipment supplier. Personnel must have three years

minimum experience with industrial and institutional boiler plant controls and instruments similar to those being furnished for this project.

1.6 AS-BUILT DOCUMENTATION

A. Submit manufacturer's literature and data updated to include submittal review comments and any equipment substitutions.

B. Submit operation and maintenance data updated to include submittal review comments, VA approved substitutions and construction revisions shall be in electronic version on CD or DVD inserted into a three-ring binder. All aspects of system operation and maintenance procedures, including applicable piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices shall be included. A List of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.

C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the 'third party testing company' requirement. Provide record drawings as follows:

   1. Red-lined, hand-marked drawings are to be provided, with one paper copy and a scanned PDF version of the hand-marked drawings provided on CD or DVD.

   2. As-built drawings are to be provided, with a copy of them on AutoCAD version 16 provided on CD or DVD. The CAD drawings shall use multiple line layers with a separate individual layer for each system.

D. The as-built drawings shall indicate the location and type of all lockout/tagout points for all energy sources for all equipment and

pumps to include breaker location and numbers, valve tag numbers, etc. Coordinate lockout/tagout procedures and practices with local VA requirements.

E. Certification documentation shall be provided to COR 21 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and provide documentation/certification that all results of tests were within limits specified. Test results shall contain written sequence of test procedure with written test results annotated at each step along with the expected outcome or setpoint. The results shall include all readings, including but not limited to data on device (make, model and performance characteristics), normal pressures, switch ranges, trip points, amp readings, and calibration data to include equipment serial numbers or individual identifications, etc.

PART 2 – PRODUCTS

2.1 MAJOR SYSTEM COMPONENTS

A. Major system components per boiler shall include but not limited to:
   1. Rockwell/Allen Bradley Compact Logix Programmable Control Processor.
   2. 12 Inch Panel View Plus Color Touch Screen HMI.
   3. Ethernet IP Backbone using HTML and XML for communication with 4-20mA, 1-5VDC, and/or 0-10VDC Actuators, and Burner Management Control.
   4. Various Controller Input/Output Modules.
   5. One Burner Management Controller and Wiring Sub-Base.
   6. One Flame Scanner: UV Self-Check.
   7. One Flame Amplifier, to correspond with the selected Flame Scanner.
   8. Various Temperature and Pressure Sensors.
   9. Alarm Bell and horn.
   10. Additional components listed within this section.
   11. All control, command, and feedback signals shall be either 4-20mA, 1-5VDC, or 0-10VDC.

B. Major functions that the Boiler Control System shall provide but not limited to:

1. Automatic sequencing of the boiler through standby, pre-purge, pilot flame establishing period, main flame establishing period, run and post purge.
2. Flame proving and lockout on flame failure during pilot flame proving, main flame proving, or run.
3. Low fire damper/valve position external proving switches for flame ignition trials.
4. Parallel Positioning Combustion Control for Air, FGR, and maximum of 3 Fuels.
5. Variable Speed Drive on Combustion Air Fan Blower Motor.
6. O2 Trim (Air Trim on the VFD).
7. Utilize solid state controls and sensors to provide various control functions, such as:
    a. Parallel Positioning Full Modulation.
    b. Modulating Control algorithm shall be Proportional-Integral-Derivative (PID) type.
    c. Thermal Shock Protection with water temperature monitoring and set point.
    d. Various High and Low limit alarms and shutdowns.
8. Touch Screen graphical operator interface and monitoring.
    a. Minimum 12 Inch Panel View Plus Color HMI.
    b. Manual control of the boiler-firing rate utilizing control screens on the HMI to increment and decrement the firing rate.
    c. Interface to commission boilers combustion and other system set points.
    d. On screen real-time display of all connected process parameters.
    e. On screen commissioning of boiler set points and configurable alarms.
    f. On screen display of system alarms and faults.
    g. On screen water level indication and alarm(s).
9. E-mail of boiler alarms.
10. Building/Plant Automation System interface.
11. High Stack Flue Gas Temperature Monitoring, Cut-Off and Alarm.
12. Low O2 cut-off and alarm.
13. Tamper resistant control logic and password protection.

14. Dual Set Point Capabilities.
15. Combustion Air Temperature.
16. Boiler Shell Water Temperature.
17. Boiler Drum Water Level Indication.
18. Modulation.
19. Firing Rate Set Point control.
20. Assured Low Fire Cut-Off (ALFCO).
21. Boiler Hot stand-by with Common Header Pressure Transmitter.
22. Hot Standby (For keeping Boilers warm - Display only).
23. PLC based expanded diagnostics.
24. Alarm Silencer via touch screen HMI.
25. Additional functions listed within this section.

C. The Boiler Control System shall provide the following safety provisions for:
   1. Integrated Burner Management:
      a. Examine all load terminals to assure it is capable of recognizing the true status of the external controls, limits and interlocks. If any input fails this test, the burner management system should lockout on safety shutdown.
      b. Closed-loop logic test verifies integrity of safety critical loads (ignition, pilot, and main fuel valves) and must be able to lockout on safety. shutdown if any safety critical load is identified as proper or improper.
      c. Pre-ignition interlocks (fuel valve proof of closure, etc.) and flames signal checked during Standby and Pre-Purge.
      d. Dynamic checking of the flame signal amplifier. The control flame signal amplifier must be able to recognize a no flame signal during this dynamic amplifier check.
      e. Safe start check and expand check to include monitoring flame signal during standby.
      f. High and Low fire switches checked for proper sequencing.
      g. Tamper-proof Purge Timing and safety logic.

2. Integrated Boiler Operating Controls and Security features
   a. Operating and Modulating Control.
   b. Password protection of Programmable Controller logic.
   c. Password protection of Parallel Positioning Set Up and Commissioning screens
   d. Password protection of Critical Set Point Screens
   e. All passwords shall be turned over to the COR.
3. The Boiler Control System shall provide annunciation and diagnostics:
   a. Active Alarm Annunciation
   b. Provide historical alarm information for on screen display.
   c. Indication of failures at start up or during normal operation.
   d. Capability of alarm history of date, time, cycle of occurrence and date and time of acknowledgement up to the most recent 100 faults.
   e. Detects and isolates an alarm and reports internal circuit faults.
   f. Primary and Secondary Low Water Shutdown and Low/High Alarms.
4. The Boiler Control System shall be able to operate in these environmental conditions.
   a. Supply Voltage: 120vac (+10%/-15%) 50 or 60 Hz.
   b. Maximum total connected load: 2000 VA.
   c. Operating temperature limits: 32 to 130 degrees F
   d. 85% RH continuous, non-condensing, humidity.
   e. 0.5G continuous vibration.
5. All Boiler Control System wiring shall be in accordance with the National Electrical Codes and local electrical codes.
6. System shall meet current NFPA 85 requirements.
7. Boiler Control System component functions shall be as follows:
   a. Burner Management Controller: Provides boiler sequencing logic to meet FM/IRI/UL approval body requirements.
   b. Touch Screen Graphical Interface (12 Inch Color Minimum): Provides user interface to the control system, boiler overview screen with connected boiler parameter readouts, alarm screens, water level indication, and system firing rate screen.

c. Ethernet IP Backbone using HTML and XML for communication with 4-20mA, 1-5VDC, and/or 0-10VDC Actuators, and Burner Management System.
d. Various Programmable Controller Input/Output modules: Provides interface for discrete powered and/or isolated relay signals, as well as for analog signals, to and from external devices.
e. Stack Temperature Sensor: Measures and transmits a signal to the Programmable Controller in relation to boiler exit flue gas temperature for indication. Also used for high stack temperature alarm and shutdown.
f. Steam Pressure Transmitter for Steam Boilers: Provides an analog signal to the Programmable Controller for indication of boiler steam pressure. Utilized for modulating control of the burner. No automatic or automated starting of boilers allowed.
g. Water (shell) Temperature Sensor on Steam Boilers: Measures and transmits a signal to the Programmable Controller in relation to boiler water temperature. Used for indication, hot standby, and thermal shock protection.

8. Additional Equipment Control Features to include:
   a. Three Boiler with Hot standby (With common header pressure transmitter). No automatic or automated starting of boilers allowed.
   b. Master Panel with Hot stand-by control for up to (3) Multiple Boiler Systems. No automatic or automated starting of boilers allowed.
   c. Combustion Air Temperature Sensor: Measures and transmits a signal to the Programmable Controller in relation to the combustion inlet temperature for indication and calculated efficiency readout.
   d. E-Mailing of Alarms capabilities.
   e. Building/Plant Automation System interface.
   f. Remote Monitoring and Data Acquisition System (SCADA).
   g. External Control Interlock (Example: Fresh Air Damper).
   h. Economizer Flue Gas Inlet/Outlet Temperature.

i. Steam Flow measurement input. (Required Flow Meter to be provided by control system manufacturer) If input is not used it is defaulted to a 4-20 ma user defined input.
j. Feed water Flow measurement input. (Required Flow Meter to be provided by Control System manufacturer) If input is not used it is defaulted to a 4-20 ma user defined input.
k. Fuel One Flow measurement input. (Required Flow Meter to be provided by Control System manufacturer) If input is not used it is defaulted to a 4-20 ma user defined input.
l. Fuel Two Flow measurement input. (Required Flow Meter to be provided by Control System manufacturer) If input is not used it is defaulted to a 4-20 ma user defined input.
m. Economizer Feed water Inlet Temperature Input.
n. Economizer Feed water Outlet Temperature Input.
o. Feed water Control Valve output. Used with Single Element drum level control including level transmitter.

2.2 AUTOMATIC BOILER/BURNER CONTROL SYSTEM, NOT INCLUDING BURNER MANAGEMENT (FLAME SAFEGUARD)

A. Basic Description of Controllers and Control Functions:
1. Controllers shall be industrial-process-grade multi-loop programmable microprocessor or programmable logic controllers (PLC).
2. Controllers shall be manufactured separate from and shall be separate assemblies, in a separate electrical cabinet from the Burner Management (Flame Safeguard System).
3. Control functions:
a. Control of burner firing rates to maintain steam header pressure.
b. Parallel-positioning combustion control (air/fuel ratio, excess air) with flue gas oxygen trim.
c. Flue gas recirculation (FGR).
d. Boiler water level, 1 element system.
4. Control features:
a. Operator interface on controller faceplates and touch screens and computer workstation. Operator interface shall include manual/automatic selection, manual loading, and displays that show set point, process variable, and signal to actuator, process

status and controller status. Touch screens have additional display requirements; refer to the following paragraph.

b. Provide separate dedicated controllers/panels for each boiler and for the master steam pressure control. Fuel/air control loops, including FGR and oxygen trim may be incorporated into one station for each boiler. Boiler/economizer outlet draft and boiler water level control shall have separate stations for each item on each boiler. All control items for one boiler may be shown on one touchscreen for that boiler. Each boiler shall have its own touch screen located in the panel for that boiler.

c. VA Boiler Plants PROHIBIT any boiler to be automatically or remotely started and lead lag control systems are prohibited within the VA boiler plants, regardless of the size or type of boiler. The boiler shall be started by an operator standing at the boiler.

d. Preferred controller/actuator signal to be either 4-20mA, 1-5 VDC or 0-10 VDC for command and feedback signals.

e. Variable frequency drives on forced draft fan motors.

5. Refer to paragraph, BURNER MANAGEMENT (FLAME SAFEGUARD CONTROL) SYSTEM WITH SAFETY INTERLOCKS AND ACCESSORIES for burner management controls.

B. Controllers: Multiple-loop programmable microprocessor or programmable logic (PLC) proportional-integral-differential (PID) solid state electronic controllers shall control all functions except burner management.

1. Accuracy: 0.1 percent analog inputs and outputs.
2. Resolution: 16-bit input and output.
3. Environment: 0 to 50 degrees C (32 to 122 degrees F), 15 percent to 95 percent RH, non-condensing.
4. As a minimum, each controller shall have capability for four analog and four digital inputs, two analog and four digital outputs, and two PID loops.
5. Memory retention for twelve months minimum for power failure or for storage as spare parts.
6. Membrane push buttons with tactile feedback (Not required for touchscreen).

7. Displays shall be a combination of English language, color graphics, and digital with 0.5 percent resolution, visible from wide angle.
8. Bumpless manual/automatic transfer.
9. High and low alarms for all inputs.
10. Programming: Controllers shall have capability for quick (5 to 10 minutes) reloading of memory by operating personnel upon memory loss. Provide all software and hardware necessary to allow field downloading of configuration memory to the microprocessors.
    a. The controller programming must be independent of the touchscreen display and PLC.
    b. The touchscreen display may NOT be the primary means of programming the PLC that runs the boilers.
    c. The boilers must remain operable and NOT shut down in the event of a touchscreen or PLC failure. In the event of a touchscreen or PLC failure, the plant operator shall be able to maintain boiler operations using the plant master panel or operator workstation.
11. Password Protection: Provide levels of password protection for all safety related options and parameters including all commissioning programming. Provide all passwords to COR.
12. In the event of a controller fault, the controller shall have a dedicated relay output that results in the shutdown of the associated boiler and provides an alarm to a panel-mounted light and audible alarm. Failure of control system for one boiler shall not affect automatic and manual operation of other boilers, via from their associated controller or the central controller.
13. Controllers and software that operate variable frequency drives shall be manufactured and tested in accordance with UL 508.
14. Controllers shall provide Ethernet communication with computer workstation running latest Microsoft Windows based operating system. This includes data gathering and processing, report generation, monitoring, annunciation and control. Refer to paragraph, COMPUTER WORKSTATION AND PROGRAMMING. It shall be possible to defeat the remote control from the front panel of each individual controller, preventing any status changes from being initiated at the computer workstation.

15. All controllers, including those assigned to data processing, shall be same model and series.
16. Controllers shall be the current generation product that will be supported by the manufacturer, with parts and service, for a minimum of ten years from time of installation.
17. All controllers shall be mounted within specified control panels.
18. All controllers with integrated flame safeguard are prohibited.

C. Power Supplies: Provide separate uninterrupted power supply for each boiler controller. Any signal that is common to all boilers, such as plant master control signals, shall be isolated from all other boilers so that failure in one boiler circuit will not affect other boilers.

D. Touch Screen Operator Terminals:
1. Provide one touch screen control station and display for each boiler mounted on the boiler control panel. Touch screen shall be in complete communication with all controllers associated with the boiler and with the burner management system. Control station to replace touch screen control functions if touch screen fails.
   a. All tools, hand-held devices required for boiler controls are required to be provided on this project.
2. Control Station and Display Requirements:
   a. Local operation of controllers, graphic display of information, alarm message display, historical and real-time trending, remote controller tuning, x/y plots of fuel air curve data for intuitive commissioning of controllers, Network to boiler control and burner management systems.
   b. Selection of automatic or manual control of firing rate. Local manual control to increase and decrease the firing rate.
   c. Indicate burner management control status and diagnostics in English messages: control on, pre-purge, trial for ignition, igniter flame signal, main flame signal, post purge, burner off, all diagnostic information available from burner management system, continuous indication of flame signal.
   d. Real time display of all connected process parameters including control output, set point, process variable, all data gathering and processing from all controllers associated with the boiler.

e. Display of all control system alarm messages and faults. History of alarms and faults and recommendations for troubleshooting.
f. Complete display and facilities to allow programming all controllers associated with the boiler or the master control. Burner management is excluded from this requirement.
g. Provide alternate means of automatic and manual operation of boiler firing rates and burner management status if touch-screen fails.
h. Provide continuous display of critical operating parameters, including but not limited to the following:
   1) Steam Pressure
   2) Water Level
   3) Draft Pressure
   4) Firing Rate

3. Touch Screen System Hardware and Software:
   a. 12" minimum panel-mounted display, TFT with 256 colors, 1280 x 800 pixel LCD resolution, at a minimum. Locate to allow easy viewing and access from operating floor.
   b. Aluminum case allowing entire enclosure to be rated NEMA 4X.
   c. Communication with Supervisory Control and Data Acquisition (SCADA) program on computer workstation.
   d. Multiple RS485 Modbus communication interfaces and Ethernet IP.
   e. Field-replaceable backlight, real-time clock, battery-backed clock time stamps critical data, 512 MB on-board flash application memory, 1 GB memory-card, application expanded memory-card for historical, alarm and event storage, resistive analog touch screen with free formable to fit target shape.
   f. Operation interaction shall be touch-based allowing easy selection of screens, manual/automatic status changes, start/stop functions, set point changes, output changes and PID tuning parameters without any special programming skills. Screen selection shall also be available through tactile feedback function keys.
   g. Show facsimiles of each controller and clearly labeled English language and engineering unit display of the control parameters.

h. Graphic X/Y curve data plotting capability. When used in conjunction with fuel/air ratio control, provide automated fuel/air ratio curve and oxygen trim set point curve adjustment for rapid, error free burner tune-up. Only a single operator action shall be required to store commissioning data into multiple characterizer curves for a particular load point.

i. Configuration software Microsoft Windows based. Provide all necessary software to allow field modification or expansion of the system including graphics drawing programs and data base builders. Systems based on "run time only" programs are not acceptable.

E. Drive Units and Actuators for Dampers, Fuel Flow Control Valves, Feedwater Flow Control Valves:

1. Electric drive units are required.
2. Electric drive units shall have continuous modulating duty cycle without any duty cycle or thermal motor limitations. Shall start instantaneously at full rated torque, stop instantaneously without coast or overshoot. Shall smoothly operate all connected devices without overload. Provide 100 percent duty cycle maintenance free motors that never overheat or burnout under stalled conditions. Gearing shall eliminate backlash. Movement shall be constant speed and shall be coordinated with the controlled process so that performance parameters remain within specified limits.
3. Additional Requirements for Electric Drive Units on Parallel-Positioning Combustion Control Systems:

a. Drive units shall have precise positioning and repeatability to provide air-fuel positioning ratios with a maximum hysteresis of 2 percent.

b. Provide continuous precise feedback signals from drive units to controllers.

c. Provide auxiliary contacts to prove low and high fire positions. Feedback signals are prohibited to perform this function within the VA. Belt-type drive units are prohibited.

d. Drive unit shafts shall be keyed to fuel flow control valves and damper shafts to eliminate the possibility of slipping.

e. Drive units shall be industrial rated.

f. All gearing shall be brass or better. Plastic gears of any kind are prohibited.

4. Boiler outlet damper drive units may be different model than drive units for fuel valves and forced draft damper. Drive units shall be capable of 136 Nm (100 ft-lb.) torque minimum. Less powerful drive units may be utilized if certified as adequate by the burner manufacturer.

F. Variable Frequency Drives (VFD) for Forced Draft Fans:

1. Refer to Section 26 29 11, MOTOR CONTROLLERS, for electrical requirements. In addition, there shall be a VFD mounted operator interface unit that allows configuration of drive parameters and displays diagnostic information for troubleshooting. The minimum speed is limited to 40 Hz.
2. Provide feedback system including motor speed and direction of rotation to combustion controller. Feedback transmitter must have no-drift guarantee. Feedback system shall not be affected by position of HOA switch on motor control system.
3. Provide noise filters.
4. The VFD shall automatically limit the rate of fan speed increase to that which will prevent an over-current trip in the event of a “step” speed increase of 0 to 100 percent.
5. Provide constant speed feature and operator-selectable air/fuel program in the controller for constant speed operation maintaining specified air/fuel ratios at all firing rates or positions (excess air).
6. Forced draft fan damper operation is required in conjunction with operation of the VFD at the lower firing rates.
7. Provide a means of proving fan RPM to control set point at any firing rate. Deviation from set point RPM or greater than 10 percent will cause a safety shutdown of the boiler.

G. Transmitters: See paragraphs, PRESSURE SENSORS AND TRANSMITTERS and TEMPERATURE SENSORS AND TRANSMITTERS.

H. Final Control Elements:

1. Fuel flow control valves, forced draft fan dampers, FGR dampers (if provided), variable frequency forced draft fan drives (VFD) (if

provided), feedwater control valves: Refer to Section 23 52 39, FIRE-TUBE BOILERS.

2. Dampers in stacks and breechings: Refer to Section 23 51 00, BREECHINGS, CHIMNEYS, AND STACKS.

I. Uninterrupted Power Supplies:

1. Provide separate complete protected power conditioners for each boiler control and for master control. Power supply shall protect all computers, controls, instruments and accessories from damage due to ground leakage, spikes, sags, surges, transients and overloads in the incoming power supply.
2. Line interactive, UL 1449 rated, interactive digital display. Automatic internal bypass. Smooth sine wave output.
3. Suitable for ambient temperature of 43 degrees C (110 degrees F) in boiler room panel.
4. Hot swappable batteries.
5. Audible and visual alarms to signal failure of power supply.
6. This UPS system can be deleted from the project if controls furnished have integral protection from power supply irregularities listed above, and if software can be immediately reloaded by plant personnel.

J. Spare Parts and Tools:

1. Master control steam pressure transmitter: One complete unit, calibrated for the service.
2. Hardware and software sufficient for downloading and uploading all programming configurations with all the controllers.
3. Electric power drive unit: One of each size and type used.
4. Touch Screen for each unique Operator Terminal.
5. All required tools, hand-held devices, etc. to be provided on this project.

K. Detailed Control Functions:

1. Control of Burner Firing Rates to Maintain Steam Header Pressure:
   a. Automatic modulation of burner firing rates on all boilers to maintain set pressure of main steam-header. Master controller receives signal from header pressure transmitter, processes and transmits signal to submaster controller for each boiler/burner.

Submaster controls fuel flow and combustion air flow. No automatic remote starting of boilers.

b. Set Points and Performance: Accuracy plus or minus two percent of the set pressure when steam load changes do not exceed 20 percent of the maximum continuous rating of the largest boiler in service in a 60 second period. System oscillations shall be minimal. Individual set point adjustment range: +/- 138 kPa (20 psig).

c. Control Stations: Individual control stations for master and submaster controllers. Locate control stations on main instrumentation panel unless otherwise shown. Master controller shall have capability for two set points with easy selection.

d. Low fire hold capability and user definable optimum ignition position.

e. Interface with burner management system for automatic positioning of forced draft fan damper and fuel flow control valves during pre-purge, ignition, shutdown and post-purge.

f. Interlocks to prove proper positions of forced draft fan damper, boiler/economizer outlet damper, and fuel flow control valves for ignition and running cycles. Refer to paragraph, BURNER MANAGEMENT (FLAME SAFEGUARD CONTROL) SYSTEM WITH SAFETY INTERLOCKS AND ACCESSORIES.

g. The steam header pressure transmitter(s) shall be dedicated to header pressure control. Suppressed range transmitter(s), each with range +/- 20 percent of required set point. If two set points are required that are more than 138 kPa (20 psig) apart, provide two transmitters. Locate transmitters adjacent to main steam-header. Refer to Paragraph, PRESSURE SENSORS AND TRANSMITTERS.

2. Parallel-Positioning Combustion Control (Air/Fuel Ratio, Excess Air):

a. Boiler/burner submaster controller provides firing rate signals to separate drive units (actuators) for forced draft fan dampers and for each of the fuel flow control valves and to the variable frequency drive (VFD) of the forced draft fan. Air/fuel ratio maintained by firmware and software programming of the submaster controller. Software shall be factory-programmed by the controller manufacturer only, for the specific application. Only tuning and scaling shall be performed in the field. Any and all other field adjustments are prohibited.

b. Hardware, firmware and software shall comply with UL 1998. Incorporate cross-limiting (air leading fuel on load increases, fuel leading air on load decreases) and deviation limiting (allowable tolerances on air/fuel ratio). Provide automatic burner shutdown if deviation exceeds programmed limits or if there is a controller failure. Cross-limiting and deviation limiting shall be tested and proven. If at any time it is found this was not preprogrammed at the factory and UL tested and listed the controller shall be replaced at no additional cost or time to the Government. Only tuning and scaling shall be performed in the field. Any and all other field adjustments are prohibited.

c. Provide feedback signals from drives and actuators. Fuel flow shall not increase until appropriate combustion air flow increase is proven. Combustion air flow shall not decrease until appropriate fuel flow decrease is proven. VFD feedback transmitters shall have "no-drift" guarantee.

d. Accuracy of control of drive units shall result in fuel-air positioning ratios that are specified by the burner manufacturer for efficient and safe operation with a maximum hysteresis of 2 percent. Excess air in flue gas shall conform to limits given below.

e. Manual control function accessible to operating personnel shall be confined to base loading the firing rate of the burner and shall prohibit separate control of fuel or combustion air. All other manual functions shall be password protected intended to be accessible only to qualified technicians. If system is improperly placed in a manual control mode, the system shall shutdown the boiler or maintain safe excess air levels at all times, within parameters that limit the carbon monoxide emissions to specified limits.

f. From low fire to high fire the air/fuel ratio (excess air) shall be programmed over at least ten evenly spaced increments of fuel input.
g. Control positions and display indications shall be linear in relation to firing rate. For example, 20 percent control position shall be 20 percent firing rate (20 percent of full load).
h. Mechanical connections between drive units and dampers and valves shall not have hysteresis and shall be keyed to eliminate slippage. Use of linkage systems must be minimized and submitted for approval as a deviation to the contract.
i. Excess Air and Emissions Limits - New Burners: Refer to the boiler and burner specification.
j. Excess Air and Emissions Limits - Existing Burners:
k. Minimum excess air at all loads: 15 percent
l. Maximum excess air at 20 to 39 percent of maximum firing rate: 35 percent
m. Maximum excess air at 40 to 100 percent of maximum firing rate: 25 percent
n. Consult COR if flue gas carbon monoxide exceeds 200 ppm within the excess air limits specified above.

3. Automatic Flue Gas Oxygen Trim System:
   a. Boiler/burner submaster air/fuel controller shall utilize signal from flue gas oxygen analyzer and vary the combustion air flow to maintain the specified air/fuel ratio (excess air) at all firing rates 20 percent of maximum firing rate and greater.
   b. Operation and Performance:
      1) Separate characterized set point curves for each fuel, minimum ten points per fuel. A single curve with biasing for the other fuel is not acceptable. Automatic changeover of set point curves when type of fuel being fired is changed.
      2) Maximum deviations from set points shall not exceed ten percent at any firing rate. Combustion shall not generate carbon monoxide (CO) in excess of 200 ppm at any time.
      3) At firing rates below 20 percent of maximum steam flow, trim shall automatically return to null position (no trim).
      4) Variable gain to decrease output sensitivity at low loads.

5) Adjustable high and low trim limiting. Excessive high or low trim correction, low excess air, or oxygen analyzer failure shall actuate audible and visual alarm on the boiler submaster air/fuel ratio controller. Analyzer failure shall cause system to go to null position.
6) Manual trim output shall revert to null setting when system is placed in automatic control.

c. During burner start-up and adjustment of air/fuel ratios (excess air) by service technician, trim shall be on manual control at null position.
d. Refer to paragraph, FLUE GAS OXYGEN ANALYZERS.

4. Internal Flue Gas Recirculation (FGR) Control:
   a. Automatic operation of FGR damper to control NOx emissions to required limits and to provide purging of combustibles from the FGR ducts during the pre-purge cycle.
   b. Automatically disable FGR during burner start-up cycle due to potential for flame instability. Automatically enable the FGR after the boiler flue gas outlet temperature reaches a minimum of 149 degrees C (300 degrees F).
   c. Interface with burner management system with interlocks to prove FGR dampers in proper position for pre-purge prior to ignition. Refer to paragraph, BURNER MANAGEMENT (FLAME SAFEGUARD CONTROL) SYSTEM WITH SAFETY INTERLOCKS AND ACCESSORIES.
5. Boiler Outlet Draft Control:
   a. Automatically modulate position of boiler or economizer outlet damper to maintain constant negative pressure (draft) at the flue gas outlet of the boiler. Utilize feed forward signal from the boiler/burner submaster air/fuel controller to enhance control response. Position damper open and closed during boiler start-up and shut-down cycles.
   b. Maintain draft at negative 25 Pa (0.1 inches WG) plus or minus 10 Pa (0.05 inches WG). Provide local gauge with remote indication at operator interface.
   c. Panel-mounted automatic controller, with manual/automatic feature and set point adjustment, for each boiler. Locate on main instrumentation panel unless otherwise shown.

d. Draft sensor, transmitter, and outlet damper actuator for each boiler. Refer to paragraph, PRESSURE SENSORS AND TRANSMITTERS.

e. Automatically position damper as required for pre-purge, burner ignition and shutdown. Provide damper position switch interlocked with burner management system. Refer to paragraph, BURNER MANAGEMENT (FLAME SAFEGUARD CONTROL) SYSTEM WITH SAFETY INTERLOCKS AND ACCESSORIES.

6. Boiler Water Level Control:

a. Automatically modulate the position of feedwater control valve on each boiler to maintain the water level in the boiler within plus or minus 50 mm (2 inches) of set point with instantaneous load swings of 20 percent of boiler capacity. Adjustable set point.

b. Type of System:

1) Single Element System: Utilize signal from Differential Pressure water level sensor on boiler.

c. Boiler Water Level Sensors:

1) Differential Pressure Transmitters: Provide on water tube boilers. Refer to paragraph, PRESSURE SENSORS AND TRANSMITTERS. Transmitter output to be 4-20mA, 1-5VDC, or 0-10VDC.

2) Water Level Sensing and Safety Control Systems: Provide on fire tube boilers. Refer to Section 23 52 39, FIRE-TUBE BOILERS.

d. Steam Flow Sensors: Refer to paragraph, FLOW METERS.

e. Feedwater Pressure Sensors: Refer to paragraph, PRESSURE SENSORS AND TRANSMITTERS.

f. Controller: Locate on main instrumentation panel unless otherwise shown. For controller requirements for fire tube boilers, refer to Section 23 52 39, FIRE-TUBE BOILERS.

g. Set point position as recommended by boiler manufacturer.

7. Boiler and Economizer Efficiency Calculation and Display: If not provided on the computer workstation, provide continuous automatic calculations and indication of heat-loss combustion efficiency based on flue gas outlet temperature of economizer (or boiler if economizer is not provided), flue gas oxygen, and type of fuel in use. Base calculation method on ASME Performance Test Code, HEAT

LOSS EFFICIENCY form, with no consideration for boiler radiation and unaccounted losses.

2.3 BURNER MANAGENENT (FLAME SAFEGUARD CONTROL) SYSTEM WITH SAFETY INTERLOCKS AND ACCESSORIES

A. Complete automatic safety control and monitoring system for burner ignition sequencing, operating cycle, and shut-down sequencing. System shall include microprocessor programmer, self-checking ultraviolet (UV) flame scanner and amplifier, burner cycle display, first-out diagnostic annunciation display, burner safety shutdown interlocks, communication with monitoring systems, and accessories. Mount controllers, control switches and displays in and on individual boiler control panels. Refer to paragraph, BOILER/BURNER CONTROL PANELS. All interlock devices shall be designed to permit periodic operational testing, including set points and trip points, without changing set points or programming, and in accordance with the VHA Boiler Plant Safety Devices Testing Manual.
   1. Controller shall be manufactured separately from the Burner Control System controller.
   2. Controller shall be a separate and individual assembly from any other controller.
   3. Controller shall have its own mounting and wiring base to permit the controller to be replaced without disturbing any wiring or other components.

B. Note: “Autoflame” and similar commercial grade management systems do not meet the intent of this specification or the intent of VA boiler safety standards.

C. Code Compliance: Conform to NFPA 85. All components UL listed, FM approved.

D. Operate on 102 to 132 volts; 60 Hertz ac. Operating ambient temperature range 0 to 52 degrees C (32 to 125 degrees F).

E. Flame Scanners: Provide self-checking ultraviolet (UV) scanners. Self-checking UV scanners shall have minimum checking frequency six times per minute. Position scanners so that they do not view the ignition spark. Scanner sight tubes must be non-reflective to avoid the scanner detecting the reflection of the ignition spark. UV non-self-checking scanners are prohibited because they can fail in an unsafe mode on continuously operated burners.

F. Control Features:

1. Automatic recycling on high steam pressure only.
2. Interrupted ignition.
3. Electronically prevent UV scanner sensing ignition spark. Methods include early spark termination or by phasing the firing of the ignition spark off cycle from the scanner activation.
4. Flame failure response time four seconds maximum.
5. Ten seconds trial for ignition except 15 seconds permitted on heavy oil fuel.
6. Pre-purge timing set for 4 air changes on fire tube boilers and 8 air changes on water tube boilers per NFPA 85. The exact timing must be determined by the boiler manufacturer. For example, typical pre-purge timing with wide open forced draft damper and forced draft fan at full speed has been 30 seconds for packaged fire tube boilers and 2 minutes for packaged water tube boilers. Once purge time has been determined and set it becomes burnt into the program and may not be changed.

G. Provide components that can be easily removed from the panel without disturbing wiring.

H. Memory storage and self-diagnostics of at least six most recent causes of burner shutdown, which can be accessed by operating and service personnel. Diagnostics shall include all individual interlocks.

I. Provide interface to allow remote access to detailed boiler plant operating data and memory. Provide interface with SCADA software on computer workstation to allow access to burner management memory and to current operating information.

J. Burner cycle indication on face of panel: Separate display from the touch screen. Show instantaneous status of startup, run and shutdown program. Provide indicator for control power on, ignition, main fuel valve open, and flame failure.

K. Reset button on face of panel. Separate display from the touch screen.

L. Annunciator Display and Alarm:

1. Separate display from the touch screen.
2. Locate display on outside face of panel between 1200 mm and 1500 mm (4 feet and 5 feet) above the floor provided on HMI display.

3. English language read-out with individual identification of specific interlocks. Where two or more interlocks serve the same function, individual display of each interlock is not required.
4. Indicate burner status in English messages: control on, pre-purge, trial for ignition, igniter flame signal, main flame signal, post purge, burner off.
5. Continuously indicate flame signal strength.
6. Provide first-out annunciation, including English language message, and audible alarm (horn) for each of the following interlocks:
   a. Flame failure.
   b. Purge airflow low.
   c. Combustion air low.
   d. False combustion air (switch activated with combustion air flow).
   e. High main gas fuel pressure.
   f. Low main gas fuel pressure.
   g. High oil pressure.
   h. Low oil pressure.
   i. Low igniter (pilot) gas pressure.
   j. Low oil temperature (heated oil systems only).
   k. Fuel safety shut-off valves not closed prior to ignition cycle.
   l. Low fire position not attained prior to ignition cycle.
   m. Low atomizing media (steam or air) static pressure at atomizing media service connection to burner piping.
   n. Low atomizing steam/oil differential pressure. Where burner does not maintain differential pressure provide low atomizing media pressure at burner.
   o. High steam pressure.
   p. Low water cutoff.
   q. FGR (if provided) improper damper position.
   r. Low flue gas oxygen.
   s. High furnace pressure.
   t. Building combustion air intake louver closed or make-up air ventilation system not operating.
7. Audible alarm (horn): Sounds upon all burner shutdowns except automatic recycle shutdowns on steam pressure. Provide silencing control, which automatically resets when burner control is reset.

M. Pre-Purge Timing: Integral with the programmer. Non-adjustable after initially set to suit boiler pre-purge requirements.

N. Auxiliary relays: Industrial type rated for the service, enclosed contacts.

O. Selector switches, push buttons and control switches: Heavy duty, industrial type.

P. Safety shutdown and manual reset required for, but not limited to:

1. Flame signal detected prior to ignition cycle.
2. Pre-ignition interlock open during pre-purge.
3. High fire purge interlock fails to close within ten minutes or less after firing rate drive unit is commanded to drive to high fire.
4. Low fire interlock fails to close within ten minutes or less after firing rate drive unit is commanded to drive to low fire.
5. Igniter (pilot) or main burner fails to ignite.
6. Malfunction of flame detector.
7. Malfunction of programmer.
8. Malfunction of flame signal amplifier.
9. Combustion air proving switch actuated prior to start-up of forced draft fan.
10. Lock-out interlock open during pre-purge (after 15 seconds), ignition or run period.
11. Interlock open.
12. Flame failure.
13. Building combustion air intake louvers closed or make up air ventilation system not operating.

Q. Burner Safety Shutdown Interlock Devices:

1. Basic Requirements:
   a. Adjustable Set Points.
   b. Maximum Set Point Deviation: 5 percent of full scale.
   c. Minimum Repeatability: 2 percent of full scale.
   d. Minimum Set Point Accuracy: 10 percent of full scale or 20 percent of set point.
   e. Scale range shall allow set points to be within 30 to 70 percent of full scale.
   f. Safety interlock devices shall be separate from operating control elements, such as feedback devices. This is to avoid having the

failure of an operating control device preventing the operation of the safety device. All safety devices shall be hardwired directly to the flame safeguard controller without passing thru any other device or control system.

2. Provisions for Testing of Interlocks:
   a. Installation of all interlock devices shall permit testing of set points and control operation without removing or disconnecting the devices and without adjusting set points of devices. Provide permanent connection points for test instruments, such as manometers and pressure gauges, on sensing piping and tubing. Where necessary, provide lockable valves to allow temporary isolation of device from the service to allow testing of the device. All test points shall be easily accessible from the floor or permanent work platform without the use of step ladders.
   b. All interlock device wiring shall start out at and end at a terminal strip in the main cabinet. No device shall be wire directly to another device in series without returning to the main cabinet’s terminal strip first. All series wiring will take place at the terminal strip. Wiring should be done in a manner that allows for ease of access with minimal PPE as required by NFPA 70.
   c. Safety devices are prohibited to be PLC dependent or be included in any program where the input or output can be forced, or if the program is changed, updated, etc., could have any effect on the safety device setting or function. All safety devices shall be hard wired from the device or sensor to the flame safeguard controller directly. Wiring may pass through terminal strip(s).
   d. Provide all necessary control system passwords, wiring diagrams, and step-by-step written instructions specific to that facility to COR to facilitate all interlock testing required by the VHA Boiler Plant Safety Devices Testing Manual. The written instructions shall include terminal and wire numbers for specific test where required.
   e. If the system installed cannot be tested in accordance with the VHA Boiler Plant Safety Devices Testing Manual the contractor shall provide a written step by step safety device test

procedure(s) for the devices(s) that follow and meet the intent of the VHA Boiler Plant Safety Devices Testing Manual, submitted to VA CFM CSS and VHA OCAMES for review and approvals. The Government reserves the right to reject any procedure and require the system device be replaced at no addition cost or time to the Government.

3. Forced Draft Fan Motor Operation Interlock: Provide split ring current relays on each phase of power circuits to fan motor, required on all systems.
   a. Provide push buttons to test each leg of the fan motor leads. The push buttons shall be mounted on the face of the cabinet, momentary contacts, wired in parallel with the current relays. The current drop through the current relay when the push buttons contacts are closed shall trip the burner off at any firing rate.
   b. For variable speed drives, provide signals to control system from VFD fault and run contacts and signals from VFD shaft speed feedback to prove proper fan speed for purging, low fire ignition, and for each burner load point. Contractor to provide test procedure for review and approval.
   c. Fully metered systems that measure and prove actual air flow at all firing rates may be used as a substitution. The contractor shall provide test procedures to prove the burner shuts down if proper air flow is not maintained or achieved. The procedures must be reviewed and approved by VA CFM CSS and VHA OCAMES.
   d. Any disconnects or other power shut-off devices between the location of the interlock devices and the motor shall also shutdown the power supply to the burner management control system.
4. Atomizing Air Compressor (when provided) Motor Energized Interlock:
   a. Provide split ring current relays on each phase of power circuits to the motor. In the power supply to the motor there shall be no disconnects or other power shut-off devices between the location of the interlock devices and the motor.
   b. Provide push buttons to test each leg of the fan motor leads. The push buttons shall be mounted on the face of the cabinet, momentary contacts, and wired in parallel with the current

relays. The current drop through the current relay when the push buttons contacts are closed shall trip the burner off at any firing rate.

5. Forced Draft Fan Damper, Boiler or Economizer Flue Gas Outlet Damper (if provided) Pre-Purge Position Interlock: Prove dampers wide open for pre-purge. Actuate sealed snap-action switches by levers attached directly to dampers or to damper linkages, which are pinned to prevent slippage. Parallel positioning systems may have the interlock switches in the drive units. The switches are dedicated for the flame safeguard system and perform no other function or purpose and are make or break switches.
6. Internal FGR Dampers (if provided) Position Interlock: Prove dampers positioned as required by burner manufacturer for pre-purge and firing. Actuate sealed snap-action switches by levers attached directly to dampers or to damper linkages, which are pinned to prevent slippage.
7. Pre-Purge Airflow Interlock:
   a. Sense differential pressure between two points in combustion air system where the differential pressure at high fire is significant, such as several inches water column. There must be no intervening dampers. This is typically between the wind-box and boiler outlet.
   b. Diaphragm-actuated snap-action switch designed for maximum system pressure, adjustable set point, graduated set point indicating scales.
   c. UL listed, FM approved.
   d. Provide air pressure sensing connections for test manometer so that air flow switch settings can be verified.
   e. Trip point shall prove at least 80 percent of maximum airflow.
8. Combustion Air Proving Interlock:
   a. Sense differential air pressure across the forced draft fan with no intervening dampers.
   b. Diaphragm-actuated snap-action switch designed for maximum system pressure, adjustable set point, graduated set point indicating scales.

c. UL listed, FM approved. Provide switch designed for “false combustion air” feature on start-up interlock.
d. Provide air pressure sensing connections for test manometer so that switch settings can be verified. Demonstrate that trip point is within 10 percent of minimum differential pressure over the firing range of the burner.

9. High and Low Main Burner Fuel (Gas and Oil) And Low Igniter (Pilot) Gas Pressure Interlocks:
   a. Approvals: UL listed, FM approved assembly.
   b. Snap acting switch, automatic reset. Provide graduated set point indicator, switch position indicator, adjustable set point coordinated with burner requirements either on the switch or as a part of the controller.
   c. Gas pressure switch ratings: Sustained pressure capability shall exceed two times lock-up of nearest upstream regulator.
   d. Oil pressure switch ratings: Sustained pressure capability shall exceed set pressure, plus accumulation, of oil pump safety relief valve. On heated oil system, sustained temperature capability shall exceed maximum operating temperature.
   e. Low gas pressure switches shall include integral impulse dampener to reduce the effects of pressure dips during start-up. Use of external dampeners or snubbers is prohibited.
   f. Switch Locations: Must be located where pressure is constant, as controlled by pressure regulator (if provided) on fuel train. Must be upstream of modulating fuel flow control valves.
   g. Set points shall be within 20 percent of the normal operating pressure.
   h. High pressure switches shall be piped to the service with lockable isolation valve and valved test connection so that switch can be set and tested using compressed air.

10. Low Oil Temperature Interlock (Heated Oil Only):
    a. Type: Solid-state sensor or sealed snap-acting switch, automatic reset. Provide graduated set point indicator, switch position indicator, adjustable set point coordinated with burner requirement either on the switch or as part of the controller.

b. Ratings: Sustained temperature capability shall exceed maximum oil temperature requirement.
c. Approvals: UL listed.
d. Location: Ahead of safety shut off valves.

11. Low Atomizing Media Pressure, Differential Pressure and Flow Interlocks:
    a. Type: Snap acting switch, graduated set point indicator, switch position indicator, adjustable set point coordinated with burner requirements, automatic reset.
    b. Rating: Shall exceed pressure setting of nearest upstream relief valve.
    c. Provide siphon on steam connection to protect sensing element from live steam.
    d. Approvals: UL listed, and FM approved.
    e. Locations and types of switches on atomizing media piping: Two switches required for each burner, a static pressure switch on atomizing media supply ahead of differential pressure control valve, and differential pressure flow switch with flow meter orifice on atomizing piping adjacent to burner. On burners that maintain an approximately constant differential pressure between the atomizing steam and oil, provide a steam/oil differential pressure switch instead of the flow switch at the oil burner. Burners with individual air compressors for air atomization shall be provided with one air pressure switch and compressor motor interlocks as specified above.
12. Main Fuel (Gas and Oil) Automatic Safety Shut-Off Valves Proof-Of-Closure (Over Travel) Interlocks. Provide on all automatic safety shut off valves to prove closure prior to igniter (pilot) ignition. Provide manually-actuated test circuits through the proof-of-closure switches that will demonstrate that the switches close and open properly and that the circuit is connected to the burner management system.
13. Low Fire Position of Fuel Flow Control Valves Interlocks: Sealed snap-acting switches. Actuate switches by levers attached directly to fuel valves. As an option, the switch lever may be pinned to the jackshaft to which the fuel valve proportioning cams are also pinned

or provide UL listed and FM approved position sensor (internal snap acting switches within the actuator a feedback signal may not act as any part of this safety device.) on the motor which positions the jackshaft to which all the operating levers are pinned.

14. High Boiler Steam Pressure Limit and Interlock: Operating limit switch allowing burner recycling and safety shutdown interlock switch. Refer to paragraph, BOILER TRIM, in Section 23 52 39, FIRE-TUBE BOILERS. On hot water boilers provide dual high temperature limit aquastats. The first low setting will alarm the boiler operator and the second high setting will turn off the boiler.
15. Low Boiler Water Level Interlocks: Primary and auxiliary low water burner shutdown interlocks. Refer to paragraph, BOILER TRIM, in Section 23 52 39, FIRE-TUBE BOILERS. Operation of auxiliary low water cutoff shall interrupt the power supply to the burner management control system. On hot water boilers provide dual prove flow devices wired in series so that either device will turn off the boiler and alarm the boiler operator. The devices shall be of two different types, i.e., flow switch and pressure differential transducer. Series wiring must not take place at the devices; it shall take place at the control panel terminal strip so that it can be wired for independent confirmation of failed device.
16. Low Flue Gas Oxygen Alarm and Interlock: Signals from flue gas oxygen analyzer providing low oxygen alarm and low oxygen burner shutdown. Refer to paragraph, FLUE GAS OXYGEN ANALYZERS.
17. High Furnace Pressure Interlock:
    a. Sense static pressure in furnace.
    b. Diaphragm-actuated snap-action switch, adjustable set point, set point indicating scale, designed for maximum system pressure.
    c. UL listed, FM approved.
    d. Connect to the service with a lockable isolation valve and valved test connection to allow the switch to be set and tested with pressurized air source.
18. Building Combustion Air Intake Interlock: Provide devices to prove outside air building wall louvers are open or H&V unit is in operation.

R. Automatic Programming Sequence:

1. After personnel select the fuel to be burned and operate the burner start switch, the control system shall automatically perform the following operations:
2. Prove proper operation of all interlocks except purging interlocks or prevent further progress.
3. Open all air dampers fully. This includes all dampers in the boiler outlet breeching and stack system.
4. Position FGR damper (if provided) as required by burner manufacturer to purge flue gas from recirculation duct.
5. Prove 80 percent of maximum air flow through the boiler and prove all air dampers open wide and FGR damper (if provided) in proper position.
6. Pre-purge eight air changes for water tube boilers and four air changes for fire tube boilers.
7. Return forced draft fan dampers and fuel flow control valves to low fire position.
8. Retain outlet damper wide open. If outlet draft damper modulating control system is provided and excessive draft due to wide-open damper is incompatible with the burner, automatically position the outlet damper to an acceptable position for burner ignition.
9. Prove low fire start position.
10. Sensing of flame prior to this shall cause shutdown.
11. Energize igniter and open igniter fuel automatic safety shut-off valves. Prove igniter flame in ten seconds or provide shutdown.
12. On systems with ultraviolet flame scanners, terminate ignition spark five seconds before main fuel valves open.
13. Open main fuel safety shut-off valves for fuel selected. Close igniter fuel valves within ten seconds after main fuel valves open (15 seconds on heated oil).
14. Prove main flame or provide shutdown.
15. Place FGR damper (if provided) in modulating or in fixed position as required by design of burner furnished.
16. If provided, release boiler/economizer outlet draft control damper to modulation.

17. Release burner from low fire position to automatic or manual firing rate control.
18. Provide 15 second post purge at end of burner firing cycle.
19. Close all dampers upon completion of post purge.

S. Spare Parts:
   1. One flame control programmer chassis complete.
   2. One flame control amplifier complete.
   3. One flame scanner complete with connecting leads.
   4. Twelve lamps for each type of replaceable lamp.
   5. Two of each type of relay and timer.

2.4 DEAERATOR, SURGE TANK AND PUMP CONTROL PANEL

A. Type: One free-standing factory-assembled steel enclosure with control stations, control switches, instruments and indicators on panel front and controllers, relays and other components mounted on interior sub-bases. NEMA ICS-6, Type 4X rating. Refer to drawings for installation location.

B. Panel Construction:
   1. Minimum 3.5 mm (0.134-inch) thick steel sheet with steel angle or bar reinforcement. Provide vertical reinforcement from top to bottom of panel between each large instrument opening. Provide horizontal reinforcement above and below each large instrument opening.
   2. Provide sufficient reinforcement to prevent any warping or displacement due to weight of equipment mounted on and within panel.
   3. All corners and edges shall be smooth.
   4. Finish:
      a. Exterior: Undercoat of rust-resistant primer, finish coats of textured spatter paint, medium gray.
      b. Interior: Undercoat of rust-resistant primer, finish coats of enamel, light gray or white.
   5. Provide duplex 120 v. GFI receptacle inside the panel.
   6. Provide fan-type ventilation and/or an air conditioning unit if necessary to protect equipment from overheating. Assume boiler room temperature of 38 degrees C (100 degrees F).

C. Control Features
   1. Touch screen graphical interface
   2. Deaerator and surge tank modulating water level controls

3. Chemical feed enabling relay.
4. Variable speed boiler feed pump control.
5. Transfer pump control
6. Serial, Ethernet BAS, communications capability
7. Alarm/fault annunciation.
8. 12” local interface screen.

D. Input/Output
1. Tank level – DA and Purge Tanks – analog
2. Tank temperature – DA and Purge Tanks – analog
3. DA tank analog pressure.
4. Two transfer pumps – start/stop
5. Three feedwater pumps – start/stop
6. Three feedwater pumps – speed
7. Make-up water valve – DA Tank
8. Make-up water Valve – Da Tank, Emergency
9. Make-up water valve – Surge Tank
10. Hard wired hi and lo water alarms and low water cutoff for two tanks
11. Pump proving current switch inputs for two transfer and three feedwater pumps.
12. Chemical feed enabling digital output.

E. Feed Water Pump Control
1. Pumps are arranged with a common discharge header.
2. Pumps shall be lead/lag control with assignment to the lead pump to maintain an approximate equal run time for the pumps.
3. Operation is to be based on system demand.
4. The pump speed is to be modulated to maintain common discharge pressure.

F. Transfer Pump Control
1. Pumps are arranged with a common discharge header.
2. Pumps shall be lead/lag control with assignment to the lead pump to maintain an approximate equal run time for the pumps. Automatic Start of pumps is prohibited.
3. The lead pump shall continuously run in automatic operation.

G. DA Make-up Water Level Control

1. Make-up water valve shall modulate to maintain DA tank water level. If surge tank discharge pump discharge header falls below setpoint, an alarm shall be generated at the operator workstation. All pumps shall be started/stopped by the operator, thru the control interface. No automatic control.
2. If both transfer pumps are commanded to run and the discharge header pressure continues to fall, alarm will be sounded. Operator acknowledgement is required to reset the alarm.
3. If the water level of the DA tank falls below the low water setpoint, the emergency make-up water valve shall open to maintain setpoint.

H. Surge Tank Make-up Water Level Control

1. The make-up water control valve shall be modulated to maintain tank level setpoint.
2. In the manual mode the valve shall be allowed to be commanded to any position between the full open and full closed.

I. Alarms

1. Low Water Level - If the water level of the DA or surge tank falls below alarm setpoint, an alarm will be sounded, a message with show on the HMI panel, an alarm condition will be logged to the alarm history and the appropriate stack light will be turned on.
2. Low Water Level - If the water level of the DA or surge tank falls further below the low low-level alarm setpoint, an alarm will be sounded, a message with show on the HMI panel, an alarm condition will be logged to the alarm history and the appropriate stack light will be turned on and all pumps will be shut off.
3. High Water Level - If water level of the DA or surge tank rises above alarm setpoint, an alarm will be sounded, a message with show on the HMI panel, an alarm condition will be logged to the alarm history and the appropriate stack light will be turned on.

J. Communications

1. Provide an OPC compliant Ethernet/IP port for connection to Building Automation System.
2. For monitoring, provide system interface for VA Building Automation System (BAS) on site.
3. Connect to Main Instrument and Control Panel.

2.5 MAIN INSTRUMENTATION AND CONTROL PANEL

A. Type: One free-standing factory-assembled steel enclosure with control stations, control switches, instruments and indicators on panel front and controllers, relays and other components mounted on interior sub-bases. NEMA ICS 6, Type 4X rating. Refer to drawings for arrangement and overall dimensions.

B. Panel Construction:

1. Minimum 3.5 mm (0.14 inch) thick steel sheet with steel angle or bar reinforcement. Provide vertical reinforcement from top to bottom of panel between each large instrument opening. Provide horizontal reinforcement above and below each large instrument opening.
2. Provide sufficient reinforcement to prevent any warping or displacement due to weight of equipment mounted on and within panel.
3. All corners and edges shall be smooth.
4. Rear Access Doors: Sufficient quantity to cover full height and width of panel, three-point latches with key-type locks, three hinges per door, or piano-type hinges.
5. Finish:
   a. Exterior: Undercoat of rust-resistant primer, finish coats of textured spatter paint, dark gray.
   b. Interior: Undercoat of rust-resistant primer, finish coats of enamel, light gray or white.
6. Provide duplex 120-volt GFI receptacle inside the panel.
7. Provide fan-type or panel mounted air-conditioning units for ventilation as necessary to protect equipment from overheating. The internal panel temperature shall be maintained at 32 degrees C (90 degrees F) or below. Assume boiler room temperature of 38 degrees C (100 degrees F). Compressed air coolers are prohibited.

C. Master Steam Pressure Control Station: Refer to paragraph, AUTOMATIC BOILER/BURNER CONTROL SYSTEM, NOT INCLUDING BURNER MANAGEMENT (FLAME SAFEGUARD). Unit shall be flush mounted on panel front.

D. Boiler/Burner Submaster Control Stations: Refer to paragraph, AUTOMATIC BOILER/BURNER CONTROL SYSTEM, NOT INCLUDING BURNER MANAGEMENT (FLAME SAFEGUARD). Units shall be flush mounted on panel front.

E. Touch Screens: Refer to paragraph, AUTOMATIC BOILER/BURNER CONTROL SYSTEM, NOT INCLUDING BURNER MANAGEMENT (FLAME SAFEGUARD).

F. Pressure Transmitters: Remote mounted, ½ percent accuracy, Provide gauge cock for each transmitter. Provide transmitter for steam header pressure, boiler feed header pressure for each boiler, fuel header pressures. Signal to be either 4-20mA, 1-5VDC or 0-10 VDC to pressure readouts on the control cabinets and central control.

G. Pressure Readouts: flush mounted, micrometer adjustable pointer, solid front, connected, and of indicated range. Provide readouts for steam header pressure, boiler feed header pressure for each boiler, fuel header pressures.

H. Push Button Stations and Indication Lights for Pump Control: Refer to Section 26 29 11, MOTOR CONTROLLERS. Lights shall be oil-tight, standard industrial construction, 120 volts, utilizing lamps which are readily available. Lenses shall be red and green colored, held in place by threaded ring. Push button stations shall be flush mounting, oil tight, momentary contact. Provide non-latching lamp test control on main panel.

I. Boiler Economizer Temperature Indicator Systems:
   1. Resistance Temperature Detectors (RTD) system measuring temperature at four points: feedwater in and out, flue gas in and out. Separate indicators graduated -18 to 315 degrees C (0 to 600 degrees F).
   2. Accuracy: Plus or minus 5 degrees F.
   3. Mounting: Mount indicators on instrumentation panel.
   4. Include Ethernet IP Backbone using HTML and XML for communication and modbus with computer workstation (present or future).
   5. Pressure gauges on feedwater, in and out.
   6. Thermometers at four points; feedwater in and out, and flue gas in and out.

J. Annunciator:
   1. Provide system for monitoring alarm functions listed below. Annunciator shall include alarm lights, alarm bell, integral test and acknowledge push buttons. Include Ethernet IP Backbone using HTML and XML for communication and modbus communications for use with computer workstation.
   2. Type: Multiple rectangular back-lighted windows/screens on the central display screen on which alarm functions are displayed and overlay active window/screen per occurrence; provide separate

window/screen for each alarm function. Provide test and acknowledge controls. All alarm lights shall operate independent of the PLC or if PLC fails all indicator lights will still function.

3. Operating Sequence:
   a. Condition Normal: Bell and light off.
   b. Condition Abnormal: Bell on; light flashing.
   c. Acknowledge: Bell off; light on steady.
   d. Condition Returns to Normal: Bell and light off.
   e. Test: Bell on; light flashing.
4. Alarm Sensing Systems: Provide complete wiring, controls, conduits, and accessories.
   a. Condensate Storage Tank and Feedwater Deaerator Storage Tank High and Low Water Level Alarms (4 functions): Actuated by sensors mounted on storage tanks. Refer to Section 23 50 11, BOILER PLANT MECHANICAL EQUIPMENT.
   b. High and Low Steam Header Pressure (2 functions): Actuated by adjustable automatic reset UL listed pressure switches. Range of adjustable set point 276 to 1241 kPa (40 to 180 psig), 34 kPa (5 psig) maximum differential. Provide steam siphon loops, shut-off valves.
   c. Emergency Gas Valve Closed: Actuated by switch provided with valve assembly.
   d. Oil Tanks - High and Low Level (2 functions per tank): Separate high and low-level indications for each tank. Actuated by oil tank level monitor system. Refer to Section 23 10 00, FACILITY FUEL SYSTEMS.
   e. Low Excess Air - Boiler (1 function per boiler): Actuated by flue gas oxygen analyzers. Refer to paragraph, AUTOMATIC BOILER/BURNER CONTROL SYSTEM, NOT INCLUDING BURNER MANAGEMENT (FLAME SAFEGUARD).
   f. High Natural Gas Header Pressure: Actuated by adjustable, automatic reset, pressure switch connected to gas header. Switch shall be UL listed for natural gas service. Provide shut-off cock between gas header and switch.
   g. LP Igniter (Pilot) Gas in Use - For Emergency Only: Actuated by adjustable, automatic reset, UL listed, FM approved, high

pressure switch mounted on LPG header. Range of set point 6.9 to 69 kPa (1 to 10 psig), emergency rating 30 psig.

h. Fuel Oil Temperature - High and Low (Heated Oil Only): Actuated by temperature switches located on the fuel oil header. Automatic reset, adjustable set point and dead band, UL listed, set point range 10 to 65 degrees C (50 to 150 degrees F). UL listed, removable without draining system, set point indicator.

i. Low feedwater pressure (1 function per header): Actuated by pressure switches on feedwater headers.

j. Input/Output (I/O) Modules: Provide 20 percent (2 minimum) installed spare I/O of each type for computer data acquisition system.

K. Emergency Fuel Safety Shut-Off Valve Control: Provide maintained contact, emergency safety shut-off push-pull control switches with mushroom heads on outside face of panel, control room, and at all personnel doorways, or routes of egress from the operating floor. The shut-off shall shutdown the main and igniter emergency safety shut-off valves from power source on the natural gas, and shutdown all other fuel sources. Turn off the fuel oil pumps. Valves shall remain closed and pumps remain off when switch is pulled out. Shall require a manual reset or restart.

L. Clock: Microprocessor-driven digital, 65 mm (2-1/2 inch) high wide-angle LED display, selectable 12/24 hours, enable/disable automatic daylight savings time changeover, enable/disable alternating time and date, seven-year battery-back-up memory, time base accurate to plus or minus two minutes per year.

M. Nameplates: Provide engraved plastic laminated nameplates for all devices on front of panel. Nameplates shall have white letters on black background. Mount with screws or rivets. List equipment title and identification number, such as “BOILER FEED PUMP P-1.” Do not use abbreviations.

N. Auxiliary relays: Industrial type rated for the service, enclosed contacts.

O. Selector switches, push buttons and control switches: Heavy duty, industrial type.

P. Wiring and Piping Methods:
   1. All devices mounted in and on panel shall be factory-wired and piped.
   2. All electrical contacts shall switch the phase conductor.
   3. Electric wiring: Conform to NFPA 70, all wiring in troughs, terminations in industrial class terminal blocks, terminals numbered for identification, 20 percent extra terminals. All wiring color coded and numbered using numbering system that identifies the destination. There shall be no exposed wiring connections exceeding 120 volts inside the panels. Refer to Section 23 21 11, BOILER PLANT PIPING SYSTEMS, and Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS and CABLES.
   4. Piping: Stainless steel tubing, securely mounted, terminate in fittings at top of the cabinets.

Q. Spare Parts Required:
   1. Lamps: Six of each type in panel and instruments.
   2. Touch-up paint for panel: One pint.

R. Seismic Design: Refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

2.6 BOILER/BURNER CONTROL PANELS

A. Type: Individual boiler/burner control panels with control stations, control switches, instruments and indicators on panel fronts and controllers, relays and other components mounted on interior sub-bases. Panels shall be boiler-mounted.

B. Panel Construction:
   1. NEMA ICS, Type 4X. Freestanding panels shall be minimum 3.5 mm (0.14 inch) thick steel sheet with steel angle or other reinforcement. Boiler-mounted panels shall be minimum 1.9 mm (0.075 inch) thick steel sheet. Provide sufficient reinforcement to prevent any warping or displacement due to weight of equipment mounted within panel. All corners and edges shall be smooth. Mount all equipment on sub-bases. Mount switches, reset buttons, indicators and instruments on outside face of panel.
   2. Access doors shall be full height and width of panel, dust tight gaskets, key-type locks. On freestanding panels, doors shall have three-point latches and three hinges or piano hinges.

3. Exterior finish: Undercoat of rust-resistant primer, finish coats of enamel. Color same as instrumentation panel or boiler manufacturer's standard color if panel is boiler-mounted.
4. Interior finish: Undercoat of rust-resistant primer, finish coats of enamel, white.
5. Identification: All elements on face of and on interior of panels shall be labeled. Nomenclature shall be keyed to wiring diagrams.
6. Provide fan-type or panel mounted air-conditioning units for ventilation as necessary to protect equipment from overheating. The internal panel temperature shall be maintained at 32 degrees C (90 degrees F) or below. Assume boiler room temperature of 38 degrees C (100 degrees F). Compressed air coolers are prohibited.

C. Burner Management System with Annunciator: See paragraph, BURNER MANAGEMENT (FLAME SAFEGUARD CONTROL) SYSTEM WITH SAFETY INTERLOCKS AND ACCESSORIES.

D. Boiler Control Stations or Touch Screens, burner management displays and resets: See paragraph, AUTOMATIC BOILER/BURNER CONTROL SYSTEM, NOT INCLUDING BURNER MANAGEMNT (FLAME SAFEGUARD) and paragraph, BURNER MANAGEMENT (FLAME SAFEGUARD CONTROL) SYSTEM WITH SAFETY INTERLOCKS AND ACCESSORIES.

E. Control switches on face of panel:
1. Fuel selector.
2. Burner start and stop selector (off-automatic-on).
3. Circuit breaker for power to burner control system.
4. Alarm silence.
5. Forced draft fan start-stop for D-type water tube boilers.
6. Burner stop switch with mushroom head.
7. Reset for burner management system.

F. Boiler water level alarm on face of panel (non lock-out):
1. Provide separate visual indications and audible alarm (bell) for high water and low water. Low water alarm is separate from low water cutouts and set at higher level than low water cutouts.
2. Indicating lights: Industrial, transformer type, removable amber lenses. Burner status and shutdown annunciator specified above may be used. Standard water level alarm display of water level control manufacturer may be used.

3. Alarm bell: 150 mm (6 inch) diameter. Provide silencing control, which is automatically deactivated when another alarm condition occurs.

G. Horn and Bell: Mounted high on exterior of panel, audible throughout the boiler plant. The horn is for burner management system alarms and the bell is for high and low water level alarms (not burner cutoff) (See previous paragraph).

H. Wiring and Piping Methods:
   1. All devices mounted in and on panel shall be factory-wired and piped.
   2. All electrical contacts shall switch the phase conductor.
   3. Electric wiring: Conform to NFPA 70, all wiring in troughs, terminations in industrial type terminal blocks, terminals numbered for identification, 20 percent extra terminals. Wiring shall be color-coded and numbered with numbering system that identifies the destination of each wire. There shall be no exposed wiring connections exceeding 120 volts inside the panels. All field wiring shall be brought to terminal strip in the panel and numbered at both ends. Wiring in series from one safety device to the next device is prohibited at the devices. Series wiring must take place at the terminal strip in the main cabinet.
   4. Piping: Stainless steel tubing, securely mounted, terminate in fittings at top of the cabinets.

I. Panel Certification and Testing:
   1. Manufacture and inspection of completed panels, including all wiring and components, shall comply with UL 508.
   2. Complete cabinets shall be factory tested and certified. The panel shall be labeled as complying with UL 508. A copy of the wiring diagram shall be placed in the cabinet prior to shipment.

2.7 COMPUTER WORKSTATION AND PROGRAMMING

A. The individual boiler plant controllers and instrumentation system shall be networked with a central computer workstation to provide remote operation of the controllers, custom graphic display of information, alarm message display, report generation, historical trending and remote tuning of controllers. All control functions shall be accomplished within the individual controllers and shall be monitored by the central computer so that the integrity of the control system shall not be dependent on the status of the central computer or the interconnecting network. Burner management (flame safety control) systems shall not be controllable from the workstation but shall be monitored from the workstation for status and access to historical data. Modem and software shall provide remote communication with diagnostic and status indications.

B. Hardware:

1. Microsoft Windows based desktop computer workstation with keyboard, mouse, two speakers, color graphic monitor, alarm printer, logging printer, and uninterrupted power supply. Equip with latest version Microsoft Windows operating system compatible with SCADA software furnished. The system shall be designed so that additional workstations and peripheral equipment can be added in the future. Provide all devices necessary for complete access to all features of the programs applied.
2. Desktop Computer: Comply with requirements published by SCADA software supplier for optimum performance of software furnished. System must include hardware as recommended by Microsoft for installation of Windows Business operating system. Minimum requirements are Intel Comet Lake processor, 12 MB L2 cache, 2.8 GHz, 1066 FSB; 64 GB 2933 MHz DDR4 SDRAM memory ECC (2 DIMMS); dual hard drives each 400 GB SATA, Nvidia QUADRO P1000 4 GB graphics, DVD+/-RW optical drive, integrated gigabit Ethernet, sound card, audible alarm and a battery-backed clock which counts seconds, minutes, hours, days and years. Provide two parallel ports and two serial ports, minimum.
3. Digital Flat Panel Color Monitor: TFT, 483 mm (19 inch) diagonal (nominal) screen with capability of 1600 by 1280 pixels resolution, non-interlaced, dot pitch 0.31 maximum. Minimum of True 16bit colors supported. Energy-Star compliant.
4. Keyboard: ASCII standard, QWERTY-style, enhanced 101-key consisting of at least 32 dedicated function keys and a 12-key numeric data entry section. Keys shall have tactile feedback and be permanently and clearly labeled. In addition, a set of arrow keys shall be provided for moving from the current screen of data to “next

screen”. Function keys shall have custom legends for each key to allow report generation, graphic display selection, alarm silencing, and data retrieval with single keystrokes. Provide removable continuous Mylar faceplate to exclude dust and spills.

5. Mouse: The operator interface shall minimize the use of the typewriter style keyboard through the use of a mouse and “point and click” approach to menu selection. Users shall be able to access features of the program from graphical displays through the use of the mouse.
6. Alarm Printer: Impact printer, 9-pin dot-matrix type. The printer shall have a minimum 96-character ASCII character set based on ANSI INCITS 154. The printer shall have tractor feed with adjustable sprockets for paper width up to 381 mm (15 inches), print at least 132 columns per line and have a draft quality speed of 680 characters per second. Character spacing shall be selectable at 10, 12 or 17 characters per 25 mm (1 inch) at front panel. The printer shall utilize sprocket-fed fanfold paper. The printer shall have programmable control of top-of-form. The sound level of the unit shall not exceed 55 dB(A) at 1500 mm (5 feet). Provide one box of 2000 sheets of printer paper.
7. Logging Printer: Black/color inkjet type, 20 ppm black and white - 15 ppm color - draft quality, minimum 8 scalable fonts, 4800 x 1210 dpi color, 16 MB RAM, capability of letter and legal paper size.
8. Speakers: Provided by computer manufacturer.
9. Uninterrupted Power Supply: Provide complete protected power conditioner. Line interactive, UL 1449 rated, interactive digital display. Power supply shall protect computers, controls, instruments and accessories from damage due to ground leakage, spikes, surges, sags, transients and overloads in the incoming power supply. Smooth sine wave output. Hot swappable batteries. Audible and visual alarm to signal failure of UPS.
10. Provide a desk unit for support of microcomputer, terminals and peripherals. The desk shall have a 600 x 762 mm (24 x 30 inch) workspace in addition to space for equipment. Desk shall have at least two drawers.

C. Supervisory Control and Data Acquisition (SCADA) Software:

1. Graphics Capabilities:

a. Color object-oriented graphic displays for monitoring and controlling the process, which show the actual configuration of the process. Real-time values from various field devices shall be displayed in a variety of user-configurable formats. Displays shall be standard MS Windows files. Graphic screens shall be based on objects and not individual pixels.

b. Interactive object-oriented editor or workspace that allows creation and editing of graphics using a mouse. Capability of making changes to the graphics without shutting down the system.

c. Graphic screens that are opened in configuration mode must support tiling and cascading. Tiling must have horizontal and vertical support and no overlapping when the graphic screens are viewed.

d. Size will be based on logical units; not pixels and any logical unit may be used. A design at one resolution must be able to run at a different resolution. Provide full screen option and the ability to add sizing borders to any graphic screen. Provide title bar enabled/disabled option.

e. Support 256 colors. Color changes must be selectable from editing the individual foreground, background, or edge color property for each object.

f. Provide configurable toolboxes that the user can customize as to what tools it contains and their position in the toolboxes. Provide a method to describe the function of each tool when the cursor is positioned on a particular tool.

g. As a minimum, support the following object drawing tools: rectangle, square, rounded rectangle/square, oval/circle, straight line, polylines, polygons, arcs, chords, pie shapes, text.

h. Operations that may be performed on objects or groups of objects must include: select/select all, deselect/deselect all, change color, move, nudge, cut, copy, paste, clear, duplicate, group/ungroup, align, space vertically/horizontally, grid, snap-to-grid, reshape, zoom in/out, send-to-back/bring-to-front, choice of line and fill styles, flip, search and replace tag names, undo, cursor position, rotation, space objects evenly, make objects same size, layers.

i. Provide ability to dynamically update elements in the picture. Dynamic link elements shall include: data, time, date, system information, alarm summary, pushbutton, multi-pen chart, OLE objects.

j. Multiple-pen chart link shall include: unlimited number of pens, display run time and historical data on same chart, configurable time span, configurable trend direction, configurable zoom, scrolling grid, invert high and low limits, minimum of five line styles for pens, minimum of three pre-built line makers and a customizable line marker.

k. Dynamic properties for objects must include: color changes (foreground, edge, background), fill percentage (horizontal, vertical), position/animation (horizontal, vertical, rotate, scale), script language (commands on down, up, mouse click, mouse double click, mouse move, edit), fill style (solid, hollow, horizontal, vertical, diagonal, cross hatch), edge style (solid, hollow, dash, dot, dash-dot, dash-dot-dot, null, inside frame. Provide capability to assign more than one dynamic property to an object.

l. For properties other than commands, configuration shall be by the mouse. Scripting or programming shall not be required. When building object dynamics, properties must support configuration from a dialog box, pop-up menu and user customizable dialog boxes or forms. Positioning property changes must support a method to get screen coordinates and automatically fill in the required coordinates for positioning. The user customizable dialog boxes or forms must be customizable through VBA. The system must supply the following pre-built forms: fill, rotate, position, scale, visibility, edge color, foreground color, background color, data entry, open/close picture, replace picture, open/close digital tag, toggle digital tag, acknowledge alarm.

m. The refresh rate shall be user-definable on a per object basis with the fastest being fifty milliseconds.

n. The animation of the graphics and objects shall be able to be linked to: Data acquired and stored by the system, data acquired and stored by a networked system, variables declared in the command language scripts, local and networked relational databases using SQL/ODBC.

o. Provide a wild card supported filter for assigning a data source. Provide a mathematical expression builder that is accessible from the graphic workspace.

p. Provide for easy reuse of graphic objects or groups of objects. The objects shall be intelligent Windows wizard-like objects. A library of objects shall be included: pipes, valves (manual and automatic types), pumps, motors, tanks.

q. The system must allow for bitmaps created by other systems to be imported into the graphics. Bitmaps must support a transparent mode and Metafiles must import as objects, not just bitmaps. As a minimum, the system must import .bmp, .msp, .jpg, wmf, pcx, ico, cur, psd, epr, and wpg.

r. MS Word and Excel documents must be able to live within a graphic screen, running with the graphic, not as an external call. Word and Excel toolbars must be inserted as part of the graphic toolbars.

s. Printing of graphic displays in color and black and white shall be supported via the standard MS Windows print manager in both the graphics development and runtime environments.

t. Operator entry methods shall be a flexible MS Windows NT method. Item selection and data entry shall be done with mouse or keyboard and the selected item shall be highlighted. The following data entry methods shall be supported: numeric, slider, pushbutton, ramp value, alphanumeric.

u. The system shall print a descriptive message with time stamp and user ID on the alarm printer or to an alarm file (as selected by user) whenever any of the following events occur:

alarm, alarm acknowledgement, data entry into tag, reloading database file, saving database file, restarting the system.

v. The scripting language used by the system must be MS Visual Basic for Applications (VBA) or equivalent with one of the software packages specified. Scripts shall allow users to automate operator tasks, and create automations solutions. The scripting language must use MS IntelliSense feature, exposing all methods and properties of graphic objects. Editing will be with the Visual Basic Editor (VBE), which is part of VBA. Scripting language requirements include: animation of objects, automatic generation of objects, read write and create database blocks, automatically run other applications, incorporate custom security features, create custom prompts and messages, incorporate and communicate with third party and custom Active X controls, trap bad Active X controls, write custom wizards, scripts become part of the graphic screen, the VBE must allow import and export capability, there must be a link from the graphic editor to the VBE, VBA or VBE is launched from within the system without any commands, all properties method and event of graphic object created within the graphic editor of third party Active X controls used in the graphic screen must be exposed to VBA.

2. Alarms and Message Handling:
   a. The system shall be capable of detecting alarm conditions based on the states and values of the various sensed variables whether or not the variables causing the alarms are on display. Alarm set points shall be enterable by the user upon configuration and during run time. Alarm types shall include: high high, high, low, low low, bad input from I/O, alarm disable, off scan, deadband, change of state, open, close. Support at least three priorities for each alarm type: high, medium, low.
   b. Message enabling and disabling must be controlled at the block level. The system must be capable of sending messages based on the following events: an operator event occurs; process database event occurs. In addition to alarms, the following types of blocks must be able to generate messages that report to any

transactions to and from the hardware: digital input, digital output, digital register, analog output, analog register, text.

c. The system must generate applications messages that describe database-related activity or operator entry. These messages shall be logged to alarm areas. Types of messages include: operator changes a process value, loads process database, logs into the system; any recipe upload, download or save condition; send information from a VBA script to all enabled alarm destinations; send a message from the database to all alarm destinations.
d. The system shall provide a means for placing an alarm message in one or more of the following locations: alarm summary display, alarm printer, alarm message file on disk, alarm history window.
e. Alarm messages shall be independently user-configurable as to what information is provided and its sequence within the message. The following shall be available choices: time of the alarm occurrence, name of tag causing the alarm, engineering units value, descriptor text assigned to the tag, engineering units of the tag.
f. When a new alarm condition is detected, an alarm message will be generated. If the alarm condition code text for the block is on the current display, then the text will flash until the alarm is acknowledged. Alarm acknowledgement will be performed from the keyboard or with the mouse and shall require no more than one keystroke or mouse click. The software shall include the following capabilities: alarm suspension which allows the user to specify digital tags that, when closed, cause alarms not to be generated for alarm conditions; re-alarm time which allows the system to re-generate an alarm after a user-configurable amount of time; alarm delay time which allows the user to specify a period of time for which an alarm condition must remain before an alarm is generated; close contact on alarm which allows user to specify digital tags that become closed when certain alarm conditions occur or reopened under certain conditions to allow operation of audible and visual alarms in the plant.
g. Provide an alarm summary display as a dynamic link within the graphics package. This must show a list of the pending alarms in

the system. As new alarms are detected, entries are made to the display list. Placement of alarm information and color codes shall be configurable. Alarms can be acknowledged from the summary display either individually or for all alarms in the queue.

3. Archiving and Reporting:
   a. Provide facility for automatically collecting, storing and recalling data. Recalled data shall be made available to a trend display program, a report generation program and to user-written programs.
   b. Store data in Windows-compatible files in compressed format. Entries containing time, name, value and status will be made in the file whenever the real-time value exceeds the previously stored value by a user-supplied deadband limit. A deadband value of zero will cause an entry in the file each time the real-time value is examined. Files shall be organized according to time and will contain values for multiple, named variables. The files can be placed on the hard disk or floppy disk. Provide a mechanism for on-line maintenance and automatic purging of files.
   c. The data to be collected by the archiving program will be identified through an interactive, menu-based configuration. The user will enter the tag name, collection rate, and data compression deadband value. Collection rates shall be selectable: 1 second, 2 seconds, 10 seconds, 20 seconds, 30 seconds, 1 minute, 2 minutes, 10 minutes.
   d. The operator shall be able to recall archived data from the disk to be displayed in graphic format along with real-time data. The display of archived data shall be user-configurable. It shall be possible to configure objects in graphic displays that, when selected, fetch pre-defined historical trend data from disk and display it to the operator. Attributes of pens shall be editable during run-time.
   e. The historical trend display shall be made up of the following components:

1) Pen Group: Configuration shall be used to define the particular tag names to be displayed. Along with tag names, pen color, marker style and engineering units may be defined.
2) Time Group: Configuration shall be used to define the time period over which the archived data is to be displayed.
3) Legend Group: Configuration shall be used to define the legend parameters for a historical display. Both a primary and alternate legend may be displayed.

f. The display shall support unlimited variables to be displayed on the same time/value axis simultaneously. For each entry in the display list, the operator will be able to assign a given tag name and marker to a particular line color selected from palettes of unlimited colors. The operator may also enter display engineering units ranges to cause scaling of the display. Support shall be provided for multiple, different y-axis engineering units to be displayed as appropriate.

g. The display shall have two fields of view. The top portion of the screen shall be the graphic field and will display the values of the variables (y-axis) against time (x-axis). It will also contain labels for the axes and graphs. The bottom portion of the screen shall be user-configurable to display information, such as node-names, tag names, and descriptors, pertaining to the tags in the trend display.

h. The trend object shall allow for bi-directional trending and scrolling. A movable, vertical line will act as a time cursor on the display. The date, time and values of the trends corresponding to that time will be displayed in the bottom portion of the screen. The grid of the trend object shall be scrollable. The trend shall be shifted forward or backward in time by clicking on the right/left buttons. New data shall be fetched from the historical file as appropriate. The ability to display historical data with current data on the same chart must be supported. A transparent option for the trend must be selectable. The user shall be able to “zoom” on any section of the trend display by “cutting” that section with the mouse. The software will automatically re-scale both the y-axis and the time axis and will fetch the appropriate data for the time period selected. The trend object must have a refresh rate selectable in 0.10 second increments from a minimum of 0.10 seconds to a maximum of 1800 seconds.

i. The trend display shall be printable to a black and white or color printer via the standard MS Windows NT print manager.

4. Event Scheduling:
   a. The system shall support a scheduler with time-based printing of reports.
   b. The system shall allow for scheduling of the following time-based printing of reports: Hourly, shift, daily, monthly, yearly.
5. Security Management:
   a. Provide a user-based security system which, when enabled, must allow for the creation of users with certain rights and/or privileges. These rights must include the ability to run any combination or all of the applications in the data acquisition system. The ability to allow or disallow users access to change values, such as set points and control setups, on an individual tag basis shall be supported.
   b. Groups of users, such as operators or supervisors, can be created and granted rights. All users assigned to a group obtain the rights of the group although they are tracked by the system by their individual ID. Individual members of a group may be also assigned additional rights.
   c. The system must support a tie to Windows NT security. When user-based security is enabled, an audit trail will be generated in the system, which will tag every operator action with a user ID.
   d. The system must support at least twenty separate security areas, assignable on a per-tag basis. Each tag can be assigned all of the available security areas, none of the available security areas, or up to three individual security areas. Only users with clearance for those security areas shall have the ability to change parameters. Security area names may be up to twenty characters in length.
   e. The following functions must be supported: enable/disable user-based security; define users, passwords and login names; define

groups to which users may belong; define security paths; define user and/or group rights/privileges; define security area names; define system auto-start user.

f. The ability to lock an operator or other user into the runtime graphics environment shall be provided. Disabling any combination of the following shall be supported, as configured by the user: starting other applications; switching to other applications that may be running; exiting from the system; restarting the computer using <Ctrl><Alt><Delete>; opening unauthorized screens; closing current screens; using the system menu; switching to the configuration environment; accessing the system tree.

g. The system shall allow for a login timeout setting for each user account. The system shall support manual login in and logout as well as automatic login. In addition, security information must be customizable through VBA scripting.

6. Services:

a. Training: An interactive on-line tutorial shall be provided as part of the software to teach the basic operations of the system, including graphics and tag development. The tutorial shall demonstrate the configuration operations using interactive on-screen instructions. Standard classroom courses for operators of the system that cover the configuration and use of the system shall be available.

b. Customer Support: Programming staff shall provide 24/7 support via telephone and email. Field service by programmer, or programmer-trained distributor, shall be available on two-day notice.

c. Quality Assurance: The vendor must have a formal and documented set of quality assurance procedures that are applied to the engineering design, development, and documentation of the software. The software shall have been in use by customers for at least three years.

7. Graphics: As a minimum, the following pictorial “screens” shall be available for observation:

a. Individual boilers with economizers (if provided) showing:

1) Main flame proven and approximate firing rate as shown by flame size depiction.
2) Steam output instantaneous flow rate (pressure compensated), lb/hr.
3) Steam output flow totalization (pressure compensated), lb. This is total production starting from time, day, month and year as set by operating personnel. Calculation shall be accomplished in control or instrumentation system, not in the SCADA software.
4) Steam header pressure, psig.
5) Boiler flue gas outlet temperature, °F.
6) Boiler flue gas oxygen percent. Set point of oxygen trim system (if trim provided).
7) Boiler stack opacity (if opacity monitors are provided).
8) Boiler flue gas outlet draft (if outlet draft control system is provided), inches WG.
9) Economizer flue gas outlet temperature, °F.
10) Economizer feedwater inlet temperature, °F.
11) Boiler feedwater inlet (economizer outlet) temperature, °F.
12) Signal to feedwater control valve.
13) Water level in boiler plus or minus inches from normal level.
14) Boiler plus economizer "Heat Loss" combustion efficiency not including radiation and unaccounted losses.
15) Fuel flow rate and totalization if individual boiler fuel meters are provided gpm; gallons. Totalization calculations shall be accomplished at the meters, not in the SCADA software.
16) Feedwater flow rate and totalization if boiler feedwater flow meters are provided gpm; gallons. Totalization calculations shall be accomplished at the meters, not in the SCADA software.
17) Trends of all flow, pressure and temperature data as listed above.

b. Boiler Plant:

1) Feedwater deaerator storage tank water level, inches of water.
2) Condensate storage tank water level, inches of water.
3) Oil tanks oil level, gallons of oil.
4) Pumps in operation.
5) Chemical feeders in operation.
6) Steam header pressure, psig.
7) Feedwater deaerator steam pressure, psig.
8) Emergency gas valve status (open or closed).
9) Natural gas header pressure, psig.
10) Fuel oil header pressure, psig.
11) Fuel oil header temperature (if heated oil), °F.
12) Boiler feed header pressure - each header, psig.
13) LP igniter gas header pressure psig.
14) Instrument air pressure psig.
15) Fuel oil tank and piping leak detection in operation.

8. Specific Requirements - Historical Trending:
   a. Display No. 1 (one display per boiler): Individual boiler pressure-compensated steam flow rate, lb/hr; flue gas oxygen, percent; boiler stack temperature, °F; economizer flue gas outlet temperature, °F; percent opacity (if opacity monitor is provided); fuel flow rate (if fuel meters are provided on the boilers), gpm, feedwater flow rate (if feedwater meters are provided on the boilers) gpm.
   b. Display No. 2: Pressure-compensated steam flow rate for: total of all boilers; in-plant steam line; and each distribution steam line, lb/hr; total plant fuel flow rate, scfh, gpm.
   c. Display No. 3: Outside air temperature, °F; feedwater temperature, °F; steam header pressure, psig.
9. Specific Requirements - Alarm Monitoring and Operation Log:
   a. Alarm Monitoring Sequence:
      1) Alarm occurs:
         a) Monitor flashes alarm on all displays where point is shown.
         b) Display screen point or group flashes.

c) Audible alarm sounds.
d) Identification of alarm point is displayed at bottom of monitor screen.
e) Printer logs alarm.

2) Operator acknowledges alarm:
a) Audible alarm is silenced.
b) Alarm display stops flashing but remains highlighted.

3) Point in alarm returns to normal after acknowledgment:
a) Alarm display clears.
b) Printer logs return to normal.

b. Alarm Summary Display: The alarm sequence summary display shall alert the operator when points are in alarm. The time of occurrence, point identification, type of alarm, engineering value, and point description shall appear on the display. The most recent alarm shall be shown at the top of the display, with time of occurrence displayed in hours, minutes, and seconds.

c. Operation Log: In addition to alarm conditions, this log shall also print status of pumps and burners (in service or out of service), status changes such as a transfer from auto to manual, set point change, etc., so that the resultant printout is a true and complete log of plant operations.

d. Alarm points shall include with quantity to be determined by contractor and equipment manufacturer:
1) Burner management safety control system alarms.
2) Boilers high and low water level.
3) Boilers low flue gas oxygen.
4) Condensate storage tank high and low water level.
5) Feedwater deaerator high and low water level.
6) Feedwater deaerator high and low steam pressure.
7) High and low steam header pressure.
8) Low feedwater pressure to each boiler.
9) Emergency gas valve closed.
10) High and low natural gas header pressure.
11) High and low fuel oil header pressure.

12) High and low fuel oil temperature (if heated oil is provided).
13) Propane igniter gas header pressurized (normal is zero pressure).
14) High and low oil level in each oil tank.
15) Oil tank and piping system leak detected.
16) Carbon monoxide (CO) or combustible gas in building.
17) Control system faults.
18) Emergency generator status.

10. Report Generation – Specific Requirements: The monitor shall display and the log sheet printer shall print out: instant, hourly, shift, daily and monthly plant operating reports. As a minimum, each report shall list:
   a. Maximum simultaneous instantaneous steam flow rate, combination of all boilers, lb/hr.
   b. Minimum simultaneous instantaneous steam flow rate, combination of all boilers, lb/hr.
   c. Totalization of steam produced, each boiler and combination of all boilers, lb.
   d. Totalization of steam used in boiler plant, lb.
   e. Separate totalization of steam exported into each distribution system, lb.
   f. Totalization of oil consumed, gallons.
   g. Totalization of natural gas consumed, mscf.
   h. Totalization of feedwater consumed, each boiler, gallons.
   i. Overall boiler efficiency, fuel vs. steam (combination of all boilers).
   j. Electricity used, kWh.
   k. Make-up water used, gallons.
   l. Make-up water as a percent of total steam production of all boilers combined.
   m. Number of heating degree-days.
   n. Hours of operation of each boiler.

11. Communication with Burner Management (Flame Safeguard) Control Systems: Provide means to communicate with each burner safety control system to determine status, operating hours, flame signal

strength, history of lockouts, number of short circuit events, other data necessary for remote trouble-shooting.

12. Monitor Screen Printout: Any display on the screen shall be able to be printed as required to provide hard-copy record.

D. Sensors and Transmitters: Provide as necessary to satisfy programming requirements. Refer to paragraphs, PRESSURE SENSORS AND TRANSMITTERS and TEMPERATURE SENSORS AND TRANSMITTERS.

2.8 FLUE GAS OXYGEN ANALYZERS

A. Oxygen content of flue gases of each boiler measured by zirconium-oxide in-situ systems with probe mounted in stack or breeching. Output to computer workstation. Single range, 0 to 10 percent oxygen.

B. Performance:

1. Minimum accuracy of plus or minus 2 percent of reading.
2. Speed of response eight seconds or less to 90 percent accurate reading.
3. Resolution 0.1 percent oxygen.
4. These performance requirements are minimums and must be increased if necessary to suit the requirements of the oxygen trim system (if provided).

C. Field-serviceable cell, heater, and cell temperature sensor.

D. Reference and Calibration Air (if required by units furnished): Provide refrigerated air dryer and instrument quality compressed air supply to each unit. Coalescing color-change filter and pressure regulator at each analyzer.

E. Automatic Calibration System: In-stack using bottled calibration gas mixtures containing oxygen and nitrogen. Number of mixtures and composition as recommended by analyzer manufacturer. See paragraph, TOOLS.

1. Selectable manual/automatic calibration, which will operate at preprogrammed intervals and upon power-up.
2. Calibration gas piping system with permanently installed stop valves, pressure and flow regulators, pressure gauges, and flow meters to permit connection of gas bottles to unit. Locate all gas bottle connections, regulators, gauges and valves accessible from floor without use of ladders.

F. Analyzer Displays: Operating parameters, process and diagnostic data, including percent oxygen, cell temperature, and set points of alarms and burner cutouts.

G. Analyzer Outputs:

1. Communications and analog output compatible with the computer workstation and all associated control elements.
2. Low flue gas oxygen alarm on computer workstation. Interface with burner management system to provide low oxygen shutdown of burner. Set point adjustable 0.5 to 3.0 percent oxygen. Set points shall not be adjustable from the front of the panel. Refer to paragraph, BURNER MANAGEMENT (FLAME SAFEGUARD CONTROL) SYSTEM WITH SAFETY INTERLOCKS AND ACCESSORIES.

2.9 FLOW METERS

A. Vortex Flow Meters with Transmitters:

1. Provide vortex-shedding flow meters designed for accurate measurement of flow rate ranges shown at required pressures. Minimum turndown capability shall be as scheduled. Meters shall have digital readout of pressure-compensated flow rate and totalization located at transmitter and transmit flow rate and totalization digital signals to the computer workstation. As an option, pressure compensation and the compensated flow rate may be performed and displayed by a boiler plant controller receiving signals from the flow meter and from a pressure transmitter. Refer to paragraph, PRESSURE SENSORS AND TRANSMITTERS.
2. Programmable microprocessor electronics with on-board programming. Output signals immune to ambient temperature swings. Continuous self-diagnostic routines that identify electronics problems and provide a warning. Electronics replaceable in the field without affecting metering accuracy. Provide power supply as recommended by meter manufacturer. Mount electronics separate from meter body in position accessible from platform or floor without the use of a portable ladder.
3. All welded wafer-type or flanged stainless-steel meter body with no seals. No sensor parts exposed to the flow stream. Provide alignment rings with wafer-type meters to assure proper centering in the pipeline. Trapezoidal shedder bar, sensing by detecting stresses in

the shedder bar caused by vortices, dual piezoelectric crystals located outside the process flow sense the shed vortices, dual crystal alignment cancels effects of noise and vibration. Designed for Schedule 40 or 80 piping per piping system requirement.

4. Transmitted signal accuracy plus or minus 1.5 percent of flow rate. Repeatability 0.2 percent of actual flow rate. Meter designed to minimize vibration effect and to provide elimination of this effect.

B. Water Flow Meters:
1. Type: Vortex Flow Meters with Transmitters and meter-mounted totalizing registers.
2. Service: Provide individual meters to measure volume of cold water, soft water as shown.
3. Performance: Conform to scheduled flow range, accuracy, maximum pressure drop, maximum static pressure and temperature for the liquid shown. Minimum accuracy plus or minus 0.5 percent of flowrate over 4/1 turndown.
4. Meter Construction:
   a. Refer to **Vortex Flow Meters with Transmitters** this specification for requirements.
   b. Registers: Hermetically sealed, magnetic coupling, digital flow rate readout or sweep hand registering one or ten gallons per revolution and digital register for totalizer with at least five digits. Provide horizontal register box with gasketed viewing glass and hinged cover. Register shall have capability of being positioned to any of the four cardinal points for readability. Transmit flow data to computer workstation.

C. Fuel Oil Meters:
1. Type: Vortex Flow Meters with Transmitters, seals, threaded pipe connections, designed for pressure exceeding set pressure, plus 25 percent, of nearest upstream relief valve. Rated for 121 degrees C (250 degrees F) if utilized for heated oil. Accuracy plus or minus 0.1 percent of flow rate over required flow range.
2. Meter Registers: Hermetically sealed flow computer with digital flow rate readout and digital register for totalizer with at least five digits located at meter, positioned for easy viewing. Transmit flow data to computer workstation.

D. Vortex Flow Natural Gas Flow Meters:

1. Type: Vortex Flow Meters with Transmitters and volume totalizing digital readout that is continuously updated and corrected for the line pressure and temperature. Meter readouts shall be located on meter and in computer workstation. Meter shall be designed for natural gas at job site characteristics.
2. Performance: Maximum flow rate as scheduled. Pressure drop shall not exceed 1.25 kPa (5 inches WG). Accurate flow minimum turndown range shall be 20/1 for the total plant meter, and 10/1 for each boiler, with minimum accuracy one percent of flow rate over the entire range.
3. Construction:
   a. Meter: Design for 861 kPa (125 psig). Pipe connections flanged 861 or 1034 kPa (125 or 150 psig) ANSI. Metering transducers operated through magnetic coupling. The measuring devices shall be contained within a module that can be removed from the meter body for service and calibration without breaking the main gas piping connections. Corrosion-resistant material of construction or coating. Refer to **Vortex Flow Meters with Transmitters** this specification for additional requirements.
   b. Indication Devices on Meter: Electronic type which provides a totalized continuous volume flow digital indication in cubic feet automatically continuously corrected to the local contract base temperature and pressure from actual varying line temperatures and pressures. Unit shall also display a totalized uncorrected volume flow indication. The display shall show actual line temperature and pressure at the meter and pressure-temperature correction factor. Smallest corrected flow indication shall be one thousand cubic feet, and indicator shall have at least six digits. Unit shall be watertight where drawings show an outdoor location.
4. Calibration: Factory calibrated. Furnish three-point curve spanning required flow range on actual meter furnished.
5. Accessories:
   a. Straightening Vanes: Provide as recommended by the meter manufacturer for the actual installation arrangement.

b. Filter: Shall have replaceable glass fiber or cellulose cartridge with ten micron or smaller particle retention. Filter enclosure shall be the pipe size of the meter or larger as required by pressure drop considerations. Static pressure capability shall be at least twice lockup pressure of service supply regulators. Maximum pressure loss 1.25 kPa (5 inches WG) at maximum design flow rate of meter. Plug all drains or instrumentation outlets. Provide vent with cock for relieving pressure in filter.

2.10 PRESSURE SENSORS AND TRANSMITTERS

A. Transmitters for gauge pressure, differential pressure, fluid level, and draft utilized for instrumentation, computer workstation, and controls.

B. "Smart" programmable electronics, sealed diaphragms, direct-sensing electronics, no mechanical force or torque transfer devices, non-interactive external span and zero adjustment, solid-state plug-in circuit boards. Minimum accuracy plus or minus 0.1 percent of calibrated span. 40:1 minimum rangeability. Communication system shall be compatible with boiler plant controls and instrumentation.

C. Shut-off and blowdown valves on all transmitters. Equalizing/calibration manifold valves on all differential pressure and fluid level transmitters. Connection points to permit calibration of system with a portable pressure calibrator.

D. Reservoirs for transmitter piping connections where an interface between liquid and steam is present, such as boiler water level sensing and differential pressure steam flow meter applications.

E. Provide and deliver to COR all hardware and software necessary for field calibrating and programming all transmitters.

F. Spare Parts: One transmitter of each type utilized in the project.

2.11 TEMPERATURE SENSORS AND TRANSMITTERS

A. Provide resistance temperature detectors (RTD).

B. Provide transmitters or panel-mounted indicator transmitters, transducers, and receivers compatible with the system including the controllers computer workstation.

C. Minimum accuracy one percent of actual temperature.

D. Boiler and economizer flue gas temperature sensors shall be averaging type and shall extend across width of stack or breeching.

E. Provide stainless steel weather hood on outside air temperature sensor, which shields the sensor from direct sunlight.

2.12 GAUGES, PRESSURE AND COMPOUND, PIPE OR TANK-MOUNTED

A. Construction:

1. Case: Solid armored front between measuring element and dial, blowout back, bottom connection, phenol turret type.
2. Dial: Non-corrosive, 115 mm (4-1/2 inch) diameter face with black markings on white background.
3. Measuring Element: Bourdon tube designed for the required service. Provide bellows designed for service for pressure ranges under 103 kPa (15 psig).
4. Movement: Stainless steel, rotary.
5. Pointer: Micrometer adjustable, black color.
6. Window: Plastic.
7. Liquid Filled Gauges: Provide at inlet and outlet of all pumps, on compressed air systems, and on fuel and atomizing media lines at locations closest to burners where bourdon tube gauges are utilized. Gauge filling shall be glycerin or silicone oil. Purpose of filling is to provide pulsation dampening. As an option to liquid filling, provide dry gauges that have built-in fluid clutch dampeners that are not vulnerable to plugging due to foreign material.

B. Accuracy: ASME B40.100, Grade 2A, 1/2 percent, on all gauges; except Grade A, one percent permitted on diaphragm actuated gauges, liquid-filled gauges, and compound gauges.

C. Accessories:

1. Red set hands on gauges located at automatic pressure regulator valve outlets.
2. Needle valve or gauge cock rated for the service.
3. Syphon on all steam gauges.
4. Pulsation snubbers on diaphragm-type gauges located adjacent to gas burners.

D. Scale Ranges: Provide dual English/metric scales:

1. Low pressure steam up to 103 kPa (15 psig): 0 to 200 kPa/0 to 29 psig.
2. Medium pressure steam up to 407 kPa (59 psig): 0 to 690 kPa/0 to 100 psig.

3. High pressure steam above 407 kPa (59 psig): 0 to 1380 kPa/0 to 200 psig.
4. Natural and LP gas: 0 to 200 kPa/0 to 29 psig.
5. LP gas at tanks: 0 to 2070 kPa/0 to 300 psig.
6. Gas burner, 125 percent of full load pressure, kPa/inches WG.
7. Oil pump suction: 100 kPa vacuum to 103 kPa/30 inches Hg vacuum to 15 psig.
8. Oil pump discharge: 0 to 1380 kPa/0 to 200 psig.
9. Oil burner, 125 percent of full load pressure, kPa/psig.
10. Compressed air, 345 kPa & higher (50 psig & higher): 0 to 1104 kPa/0 to 160 psig.
11. Feedwater pump discharge: 0 to 2070 kPa/0 to 300 psig.
12. Feedwater pump suction: 100 kPa vacuum to 200 kPa/30 inches Hg vacuum to 29 psig.
13. Pumped condensate: 0 to 414 kPa/0 to 60 psig.
14. Condensate transfer pump discharge: 0 to 414 kPa/0 to 60 psig.
15. Condensate transfer pump suction: 100 kPa vacuum to 103 kPa/30 inches Hg vacuum to 15 psig.
16. Feedwater deaerator: 100 kPa vacuum to 200 kPa/30 inches Hg vacuum to 29 psig.
17. Other services, 200 percent of maximum operating pressure.

E. Boiler Steam Pressure Gauges: Refer to Section 23 52 39, FIRE-TUBE BOILERS.
F. Panel-mounted Gauges: Refer to paragraph, MAIN INSTRUMENTATION AND CONTROL PANEL.

2.13 THERMOMETERS, PIPE OR TANK-MOUNTED

A. General: Thermometer locations are shown on the drawings.
B. Construction:
   1. Industrial type, separable well and socket, union connected.
   2. Scales: Red reading mercury combination 0 to 150 degrees Celsius/30 to 302 degrees Fahrenheit scales, unless otherwise shown. Scale length 225 mm (9 inch) except 175 mm (7 inch) scale length acceptable on oil burner piping. Mercury sealed under pressure with inert gas to prevent oxidation and separation of column.
   3. Case: Corrosion resistant with glass or plastic front.

4. Form: Straight or back form except thermometers located more than 2100 mm (7 feet) above floor or platform shall be adjustable angle.
5. Wells: Sized to suit pipe diameter without restricting flow. Provide snug sliding fit between socket and well.
6. Accuracy: One percent of scale range.

2.14 BOILER PLANT BUILDING DANGEROUS GAS DETECTION SYSTEM, CARBON MONOIDE AND COMBUSTIBLE GAS

A. Automatic microprocessor-based industrial-class system that monitors the concentration levels of carbon monoxide and combustible gases in the boiler room and associated spaces. The system shall include displays of the concentration levels of the gases detected by each sensor and provide audible and visual alarms when these gases are detected. Control/transmitter panels with displays and control functions shall be located 1500 mm (5 feet) above the boiler room floor. Provide combustibles sensors and carbon monoxide sensors at locations shown or as directed. Provide RS485 Modbus communications protocol (i.e., Modbus RTU, etc.) of detected gas concentration levels and alarms to computer workstation and central control panel. Transmit all alarm signals to the Security Control Center in Building 1 Police Station. An audible and visual alarm shall be provided at this location.
   1. Configure the system for three (2) levels of alarm.
   2. Integrate the hazardous gas detection system into the plant controls such that:
      a. Upon detection of any hazardous or flammable gas the ventilation system supply and exhaust fans shall start and ramp to 50% speed and a warning shall be initiated at the operator workstation.
      b. If hazardous or flammable gas concentration rises to the high level setpoint the supply and exhaust fans shall ramp to 100% speed, and an audible and visual alarm shall be generated at the operator workstation and the Security Control Center in Building 1.

B. System Description:
   1. Carbon Monoxide (CO) Sensors: Transportable calibration, electrochemical plug-in type, range 0 to 100 ppm, detection limit less than plus or minus 5 percent of full scale, response time less

than 10 seconds, zero drift less than 5 percent per year, span drift less than 10 percent per year, repeatability less than plus or minus 5 percent of full scale, active temperature compensation. Set point: 25 to 50 ppm.

2. Combustible Gas Sensors: Plug-in type, infrared detection, no moving parts, range 0 to 100 percent lower explosive limit. On-board storage of calibration data, peak values, time and date stamped. Set point: 10 percent of lower explosive limit.
3. Controller/Transmitters: Separate from sensors, non-intrusive calibration. NEMA 4X enclosure, sensors connected to transmitter with easily operated connection devices. Universal transmitter which can accept infrared, catalytic bead, or toxic sensor and auto-configure when sensor connector is inserted. LED display of gas type and concentration, alarm horn and strobe, output compatible for computer workstation, integral non-volatile memory, automatic resume on power failure, sensor and controller diagnostics, menu-driven calibration. Networked with computer workstation SCADA program or central control panel via RS485 four-wire bus, such as Modbus RTU.
4. Additional Features:
   a. Capability to remotely mount sensor from transmitter to allow calibration at convenient point up to 30 m (100 feet) away.
   b. Sensor/transmitter display shall indicate all diagnostic check/fault conditions with detailed message displays.
   c. Full-function keypad or magnetic touch points to allow setting alarm set points, change span gas values and display date of last calibration.
5. Calibration: Sensor/transmitters shall be calibrated with hand-held calibration devices furnished by system manufacturer. Provide complete calibration kit, including test gases, for commissioning and future calibrations. Provide permanently mounted stainless steel tubing for remote-mounted sensors.
6. Approvals: NEC and CEC for explosion proof or non-incendive, when required.
7. Product Support: Supplier shall have organization, located within 242 kilometers (150 miles) of site, with capability of complete onsite product.

8. Power Supply: Provide protected power supply to protect system from surges, spikes, transients, overloads in the incoming power supply.

PART 3 – EXECUTION

3.1 GENERAL

A. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no additional cost or time to the Government.

3.2 INSTALLATION, BOILER PLANT INSTRUMENTATION, AUTOMATIC BOILER CONTROL SYSTEMS, BURNER MANAGEMENT SYSTEMS, COMPUTER WORKSTATION (IF PROVIDED)

A. General:

1. Nameplates, Labels and Identification: Refer to Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION.
2. Electrical Work and Safety Requirements: Comply with NFPA 70 and referenced electrical sections of these specifications.
3. Electrical Wiring: Comply with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS; Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS; Section 26 05 19, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES; and Section 26 27 26, WIRING DEVICES. The term "wiring" includes furnishing of wire, conduit, miscellaneous material and labor to install a complete working system as specified.
4. All devices plumbing and wiring shall comply with and be arranged as shown in the VHA Boiler Plant Safety Devices Testing Manual.
5. Protect all circuits to avoid interruption of service or damage to equipment due to short-circuiting or other conditions. Line-protect from lightning and static electricity all wiring that comes from external sources.
6. Except for short apparatus connections, run conduit parallel to or at right angles to the building structure.
7. Run tubing and wire connecting devices in control cabinets parallel with the sides of the cabinets neatly racked to permit tracing. Rack wiring bridging a cabinet door along the hinge side and protect from damage. Provide grommets, sleeves or vinyl tape to protect plastic tubing or wires from sharp edges of panels, conduit, and other items. Fit all equipment contained in cabinets or panels with service loops; each loop shall be at least 300 mm (12 inches) long.

Equipment for fiber optic systems shall be self-supporting, code gauge steel enclosure.

8. Permanently mark terminal blocks for identification. Label or code each wire at each end. 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.
9. Cables:
   a. Keep cable runs as short as possible. Allow extra length for connecting to the terminal board.
   b. Do not bend flexible coaxial cables in a radius less than ten times the cable outside diameter.
   c. Cables shall be supported for minimum sag.
   d. Splices in shielded and coaxial cables shall consist of terminations and shielded cable couplers. Terminations shall be in accessible location. Cables shall be harnessed with cable ties.
10. Flexible conduit of any type is limited to 900 mm (3 feet) in length unless longer runs are required for access to equipment such as opening the front door of a boiler.
11. Conduit smaller than 50 mm (1/2 inch) is prohibited.
12. All electrical conductors shall be installed in conduit. (Including SO Cord).

B. Pressure, Temperature, Level and Flow Transmitters: Mount in locations accessible from floor or platform without use of portable ladders. Provide separate conduit for each transmitter signal. Protect sensor or controller on steam or water service by an adequate water seal at all times and provide blowdown facilities to permit blowdown of sensing lines. Install temperature sensors with entire temperature sensing surface immersed in media being measured. Locate outside air temperature sensor on north side of building away from heat sources. Provide isolation valves on all transmitters connected to fluid systems. Locate isolation valves so that transmitter can be isolated while main sensing line is being blown down. Provide equalizing valves on all differential pressure transmitters. Provide valved drains on all fluid lines. Valves shall be rated for minimum of 150 percent of system pressure and temperature.

C. Steam Flow Meter Primary Elements (In-Line Flow Sensors) including Vortex-Shedding Type: Provide straight runs of piping upstream and downstream as recommended by manufacturer to achieve maximum accuracy and rangeability. Verify that stresses in piping system do not exceed allowable stress of flow meter body. Locate meter electronics including read-out devices accessible from floor or platform without the use of portable ladders.

D. Flue Gas Oxygen Analyzers:

1. Mounting: Provide freestanding floor-mounted steel rack for mounting control panels and read-outs. Position panels and readouts 1500 mm (5 feet) above the boiler room floor.
2. Sampling point shall be upstream of smoke density monitor in non-turbulent area. Locate probe within 4.6 meters (15 feet) of floor or accessible from platform.
3. Reference Air: Provide dry, filtered, pressure-regulated compressed air service to each unit. Provide isolating valve at each unit.
4. Calibration Gases: Provide permanently installed valved piping connections, pressure regulators and gauges in flue gas sampling system for connection of required calibration gases. Locate within 1200 mm (4 feet) of main floor.
5. Interconnection of Instruments: Provide shielded wiring as recommended by instrument manufacturer.
6. Power Circuits: Provide dedicated circuits from a plant panel. Analyzers shall remain powered when burner control is off.

E. Wiring and Piping: Is generally not shown on the drawings. All wiring and piping must be provided in accordance with NFPA 70 and ASME B31.1.

F. Combustion Control Linkage Systems: After completion of burner adjustments, counter sink all lever set screws into shafts or pin levers to shafts to prevent levers from slipping on the shafts.

G. Boiler Stack Opacity Monitors (if provided): Locate downstream from oxygen sensing systems so that opacity monitor air purge does not affect flue gas oxygen reading. Locate sensor within 15 feet of floor or accessible from platform without use of portable ladder. Locate air purge blower unit within 8 feet of floor or accessible from platform without use of portable ladder.

H. Compressed Air Filters: Pipe drain to nearest floor drain.

3.3 INSTALLATION, NATURAL GAS FLOW METERS

A. Entire installation shall conform to recommendations of the meter manufacturer for obtaining the most accurate flow measurements. Arrange meter readout so that it is visible from nearest walkway or service platform.

3.4 INSTALLATION, PRESSURE GAUGES

A. Orient gauges so that dials are upright and visible from the nearest walkway or access platform. Install gauges with gauge cocks. Provide pig-tail syphons on steam service. Provide compound gauges on all pump suction lines and on feedwater deaerator; provide pressure gauges elsewhere. Install liquid-filled or equivalent (as specified) gauges at inlet and outlet of all pumps, on compressed air systems, and on fuel and atomizing media lines at locations closest to burners. If diaphragm-type gauges are used, provide pulsation dampeners instead of liquid filling.

3.5 INSTALLATION, THERMOMETERS

A. Arrange thermometers so that scales are upright and visible from nearest walkway or access platform. Provide adjustable angle thermometers on applications more than 2100 mm (7 feet) above floor or platform. Tilt the angle type thermometers for proper view from floor or platform. Locate wells in flow stream.

3.6 INSTALLATION, WATER AND OIL FLOW METERS

A. Provide strainer upstream with 80-mesh screen liner. Refer to Section 23 21 11, BOILER PLANT PIPING SYSTEMS. Position register for upright viewing from nearest walkway.

3.7 TESTING, BOILER PLANT INSTRUMENTATION, AUTOMATIC BOILER CONTROL SYSTEMS, BURNER MANAGEMENT SYSTEMS, COMPUTER WORKSTATION (IF PROVIDED)

A. Representatives of the designer of the system shall demonstrate proper operation and calibration of all components, computer programs, and entire systems to the COR. If the project includes boiler/burner testing, the demonstration involving boiler/burner data shall be conducted during the boiler/burner tests. Furnish personnel, instrumentation, and equipment necessary to perform calibration and testing. All calibration work must be completed prior to the testing.

B. Burner Management (Safety Control) Systems: All tests shall be based on the VHA Boiler Plant Safety Devices Testing Manual, also Refer to Section 23 52 39, FIRE-TUBE BOILERS.

C. Steam Flow Measuring: Demonstrate proper calibration of each flow rate signal and indication and each totalizer signal and indication to COR or their representative prior to the start of the final boiler testing.

D. Testing shall demonstrate proper calibration of input and output devices, the proper operation of all equipment, proper execution of the sequence of operation, proper tuning of control loops and maintaining of all set points.

E. Document all tests with detailed report of test results. Explain in detail the nature of each failure and corrective action taken.

F. During and after completion of the pretests, and again after the final acceptance tests, identify, determine causes, replace, repair and calibrate equipment that fails to comply with contract requirements or the standards of the manufacturer, and retest. Provide written report to COR.

G. Demonstrate all safety and operating interlocks.

H. Demonstrate that programming is not lost and that the control and instrumentation system performs the correct sequence of control and instrument functions after a loss of power.

I. Furnish to COR graphed trends of control loops to demonstrate that the control loops are stable and that set points are maintained. Trend data shall be instantaneous and the time between data points shall not be greater than one minute.

J. Signal Transmission System Equipment:

   1. Ground Rod Tests: Before any wire is connected to the ground rods, use a portable ground testing instrument to test each ground or group of grounds.
   2. Coaxial Cable Tests: Implement NEMA WC 63.2 as a minimum.

K. Computer Workstation Software Operation Test:

   1. Test ability to properly communicate with and operate the control systems.
   2. Demonstrate the ability to edit the programs off and on line.

3. Demonstrate operation of all alarm points.
4. Demonstrate the receipt, display, and saving of trend and status reports.
5. Demonstrate display and operation of all graphics.
6. Demonstrate all program calculating functions and report generation.
7. Demonstrate proper operation of all printers.

3.8 STARTUP AND TESTING

A. Perform tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.
B. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.
C. The 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 notice of 10 working days prior to startup and testing.

3.9 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
B. Components provided under this section of the specification will be tested as part of a larger system.

3.10 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer’s technical representative for 16 hours to instruct each VA personnel responsible in operation and maintenance of the system.
B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

- - - E N D - - -

SECTION 23 09 23
DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC

PART 1 – GENERAL

1.1 DESCRIPTION

A. General Contractor shall provide direct-digital control system(s) as indicated on the project documents, point list, interoperability tables, drawings and as described in these specifications. Include a complete and working direct-digital control system. Include all engineering, programming, configuration/setup hardware and software, controls and installation materials, installation labor, commissioning and start-up, training, final project documentation and warranty.

1. The direct-digital control system(s) shall consist of high-speed, peer-to-peer network of DDC controllers, a control system server, all configuration and setup software and hardware devices, and an Engineering Control Center. Provide a remote user using Building Controllers to access the control system graphics and change adjustable setpoints with the proper password.
2. All new building controllers shall be native BACnet. All new BACNet workstations, controllers, devices and components shall be listed by BACnet Testing Laboratories. All new BACNet workstations, controllers, devices and components shall be accessible using a HTML5 Web browser interface. Browsers shall not require the use of an extension or add on software in order to access aforementioned workstations, controllers, devices, and components.
   a. If used, gateways shall be BTL listed.
   b. If used, gateways shall provide all object properties and read/write services shown on VA-approved interoperability schedules.
3. The work administered by this Section of the technical specifications shall include all labor, materials, special tools, equipment, enclosures, power supplies, software, software licenses, Project specific software configurations and database entries, interfaces, wiring, tubing, installation, labeling, engineering, calibration, documentation, submittals, testing, verification, training services, permits and licenses, transportation, shipping, handling, administration, supervision, management, insurance,

Warranty, specified services and any other items required for a complete and fully functional Controls System.

4. The control systems shall be designed such that each mechanical system shall operate under stand-alone mode. The A/E shall designate what each "mechanical systems" is composed of. The contractor administered by this Section of the technical specifications shall provide controllers for each mechanical system. In the event of a network communication failure, or the loss of any other controller, the control system shall continue to operate independently. Failure of the ECC shall have no effect on the field controllers, including those involved with global strategies.

B. Some products are furnished but not installed by the contractor administered by this Section of the technical specifications. The contractor administered by this Section of the technical specifications shall formally coordinate in writing and receive from other contractors formal acknowledgements in writing prior to submission the installation of the products. These products include but are not limited to the following:
   1. Control valves.
   2. Flow switches.
   3. Flow meters.
   4. Sensor wells and sockets in piping.
   5. Terminal unit controllers.

C. Some products are installed but not furnished by the contractor administered by this Section of the technical specifications. The contractor administered by this Section of the technical specifications shall formally coordinate in writing and receive from other contractors formal acknowledgements in writing prior to submission the procurement of the products. These products include but are not limited to the following:
   2. Factory-furnished accessory thermostats and sensors furnished with unitary equipment.

D. Some products are not provided by, but are nevertheless integrated with the work executed by, the contractor administered by this Section of the technical specifications. These products include but are not limited to the following:

1. Fire alarm systems. If zoned fire alarm is required by the project-specific requirements, this interface shall require multiple relays, which are provided and installed by the fire alarm system contractor, to be monitored.
2. Advanced utility metering systems. These systems may take information from the control system or its component meters and sensors.
3. Boiler and/or chiller controls. These controls, if not native BACnet, will require a BACnet Gateway.
4. Terminal units' velocity sensors
6. Unitary HVAC equipment (rooftop air conditioning units, split systems, packaged pumping stationscontrols. These include:
   a. Discharge temperature control.
   b. Economizer control.
   c. Flowrate control.
   d. Setpoint reset.
   e. Time of day indexing.
   f. Status alarm.
7. Variable frequency drives. These controls, if not native BACnet, will require a BACnet Gateway.
8. The following systems have limited control (as individually noted below) from the ECC:
   a. Emergency generators: status alarms.
   b. Domestic water heating systems: low temperature, high temperature and status alarms.
   c. Building lighting systems: on/off and scene control.
   d. Stormwater removal pumps: status alarm.
   e. Sanitary sewage pumps: status alarm.

E. Responsibility Table:

Work/Item/System	**Furnish**	**Install**	**Low Voltage Wiring**	**Line Power**
Control system low voltage and communication wiring	23 09 23	23 09 23	23 09 23	N/A
Terminal units	23	23	N/A	26
Controllers for terminal units	23 09 23	23	23 09 23	16
LAN conduits and raceway	23 09 23	23 09 23	N/A	N/A
Automatic dampers (not furnished with equipment)	23 09 23	23	N/A	N/A
Automatic damper actuators	23 09 23	23 09 23	23 09 23	23 09 23
Manual valves	23	23	N/A	N/A
Automatic valves	23 09 23	23	23 09 23	23 09 23
Pipe insertion devices and taps, flow and pressure stations.	23	23	N/A	N/A
Thermowells	23 09 23	23	N/A	N/A
Current Switches	23 09 23	23 09 23	23 09 23	N/A
Control Relays	23 09 23	23 09 23	23 09 23	N/A
Power distribution system monitoring interfaces	23 09 23	23 09 23	23 09 23	26
Interface with chiller/boiler controls	23 09 23	23 09 23	23 09 23	26
Chiller/boiler controls interface with control system	23	23	23 09 23	26
All control system nodes, equipment, housings, enclosures and panels.	23 09 23	23 09 23	23 09 23	26
Smoke detectors	28 31 00	28 31 00	28 31 00	28 31 00
Fire/Smoke Dampers	23	23	28 31 00	28 31 00
Smoke Dampers	23	23	28 31 00	28 31 00
Fire Dampers	23	23	N/A	N/A
Boiler interlock wiring	23	23	23	26
Boiler Flow Switches	23	23	23	N/A

Work/Item/System	**Furnish**	**Install**	**Low Voltage Wiring**	**Line Power**
Water treatment system	23	23	23	26
VFDs	23	26	23 09 23	26
Refrigerant monitors	23	23 09 23	23 09 23	26
Computer Room A/C Unit field-mounted controls	23	23	26	26
Control system interface with CRU A/C controls	23 09 23	23 09 23	23 09 23	26
CRU A/C unit controls interface with control system	23	23 09 23	23 09 23	26
Fire Alarm shutdown relay interlock wiring	28	28	28	26
Control system monitoring of fire alarm smoke control relay	28	28	23 09 23	28
Fire-fighter’s smoke control station (FSCS	28	28	28	28
Fan Coil Unit controls (not furnished with equipment)	23 09 23	23 09 23	23 09 23	26
Unit Heater controls (not furnished with equipment)	23 09 23	23 09 23	23 09 23	26
Packaged RTU space-mounted controls (not furnished with equipment)	23 09 23	23 09 23	23 09 23	26
Packaged RTU 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

F. Unitary standalone systems including Unit Heaters, , thermal comfort ventilation fans, and similar units for control of room environment 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. Mechanical or electrical room heating and ventilation.

G. The direct-digital control system shall start and stop equipment, move (position) damper actuators and valve actuators, and vary speed of equipment to execute the mission of the control system. Use electricity as the motive force for all damper and valve actuators, unless use of pneumatics as motive force is specifically granted in writing by the VA.

1.2 RELATED WORK

A. Section 23 09 11, Instrumentation and Control for Boiler Plant.
B. Section 23 22 13, Steam and Condensate Heating Piping.
C. Section 23 31 00, HVAC Ducts and Casings.
D. Section 23 52 39, Fire-Tube Boilers.
E. Section 23 81 00, Decentralized Unitary HVAC Equipment.
F. Section 26 05 11, Requirements for Electrical Installations.
G. Section 26 05 19, Low-Voltage Electrical Power Conductors and Cables (600 Volts and Below).
H. Section 26 05 26, Grounding and Bonding for Electrical Systems.
I. Section 26 05 33, Raceway and Boxes for Electrical Systems.
J. Section 26 09 23, Lighting Controls.
K. Section 26 27 26, Wiring Devices.
L. Section 26 29 11, Motor Starters.
M. Section 26 32 13, Engine Generators.
N. Section 27 15 00, Communications Horizontal Cabling
O. Section 28 31 00, Fire Detection and Alarm.

1.3 DEFINITION

A. Algorithm: A logical procedure for solving a recurrent mathematical problem; A prescribed set of well-defined rules or processes for the solution of a problem in a finite number of steps.
B. Analog: A continuously varying signal value (e.g., temperature, current, velocity etc.
C. BACnet: A Data Communication Protocol for Building Automation and Control Networks -as defined by ANSI/ASHRAE Standard 135. This

communications protocol allows diverse building automation devices to communicate data and services over a network.

D. BACnet/IP: Annex J of Standard 135. It defines and allows for using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP sub-networks that share the same BACnet network number.

E. BACnet Internetwork: Two or more BACnet networks connected with routers. The two networks may use different LAN technologies.

F. BACnet Network: One or more BACnet segments that have the same network address and are interconnected by bridges at the physical and data link layers.

G. BACnet Segment: One or more physical segments of BACnet devices on a BACnet network, connected at the physical layer by repeaters.

H. BACnet Broadcast Management Device (BBMD): A communications device which broadcasts BACnet messages to all BACnet/IP devices and other BBMDs connected to the same BACnet/IP network.

I. BACnet Interoperability Building Blocks (BIBBs): BACnet Interoperability Building Blocks (BIBBs) are collections of one or more BACnet services. These are prescribed in terms of an "A" and a "B" device. Both of these devices are nodes on a BACnet internetwork.

J. BACnet Testing Laboratories (BTL). The organization responsible for testing products for compliance with the BACnet standard, operated under the direction of BACnet International.

K. Baud: It is a signal change in a communication link. One signal change can represent one or more bits of information depending on type of transmission scheme. Simple peripheral communication is normally one bit per Baud. (e.g., Baud rate = 78,000 Baud/sec is 78,000 bits/sec, if one signal change = 1 bit).

L. Binary: A two-state system where a high signal level represents an "ON" condition and an "OFF" condition is represented by a low signal level.

M. BMP or bmp: Suffix, computerized image file, used after the period in a DOS-based computer file to show that the file is an image stored as a series of pixels.

N. Bus Topology: A network topology that physically interconnects workstations and network devices in parallel on a network segment.

O. Control Unit (CU): Generic term for any controlling unit, stand-alone, microprocessor based, digital controller residing on secondary LAN or Primary LAN, used for local controls or global controls

P. Deadband: A temperature range over which no heating or cooling is supplied, i.e., 22-25 degrees C (72-78 degrees F), as opposed to a single point change over or overlap).

Q. Device: a control system component that contains a BACnet Device Object and uses BACnet to communicate with other devices.

R. Device Object: Every BACnet device requires one Device Object, whose properties represent the network visible properties of that device. Every Device Object requires a unique Object Identifier number on the BACnet internetwork. This number is often referred to as the device instance.

S. Device Profile: A specific group of services describing BACnet capabilities of a device, as defined in ASHRAE Standard 135-2008, Annex L. Standard device profiles include BACnet Operator Workstations (B-OWS), BACnet Building Controllers (B-BC), BACnet Advanced Application Controllers (B-AAC), BACnet Application Specific Controllers (B-ASC), BACnet Smart Actuator (B-SA), and BACnet Smart Sensor (B-SS). Each device used in new construction is required to have a PICS statement listing which service and BIBBs are supported by the device.

T. Diagnostic Program: A software test program, which is used to detect and report system or peripheral malfunctions and failures. Generally, this system is performed at the initial startup of the system.

U. Direct Digital Control (DDC): Microprocessor based control including Analog/Digital conversion and program logic. A control loop or subsystem in which digital and analog information is received and processed by a microprocessor, and digital control signals are generated based on control algorithms and transmitted to field devices in order to achieve a set of predefined conditions.

V. Distributed Control System: A system in which the processing of system data is decentralized, and control decisions can and are made at the subsystem level. System operational programs and information are provided to the remote subsystems and status is reported back to the Engineering Control Center. Upon the loss of communication with the

Engineering Control center, the subsystems shall be capable of operating in a stand-alone mode using the last best available data.

W. Download: The electronic transfer of programs and data files from a central computer or operation workstation with secondary memory devices to remote computers in a network (distributed) system.

X. DXF: An AutoCAD 2-D graphics file format. Many CAD systems import and export the DXF format for graphics interchange.

Y. Electrical Control: A control circuit that operates on line or low voltage and uses a mechanical means, such as a temperature sensitive bimetal or bellows, to perform control functions, such as actuating a switch or positioning a potentiometer.

Z. Electronic Control: A control circuit that operates on low voltage and uses a solid-state components to amplify input signals and perform control functions, such as operating a relay or providing an output signal to position an actuator.

AA. Engineering Control Center (ECC): The centralized control point for the intelligent control network. The ECC comprises of personal computer and connected devices to form a single workstation.

BB. Ethernet: A trademark for a system for exchanging messages between computers on a local area network using coaxial, fiber optic, or twisted-pair cables.

CC. Firmware: Firmware is software programmed into read only memory (ROM) chips. Software may not be changed without physically altering the chip.

DD. Gateway: Communication hardware connecting two or more different protocols. It translates one protocol into equivalent concepts for the other protocol. In BACnet applications, a gateway has BACnet on one side and non-BACnet (usually proprietary) protocols on the other side.

EE. GIF: Abbreviation of Graphic interchange format.

FF. Graphic Program (GP): Program used to produce images of air handler systems, fans, chillers, pumps, and building spaces. These images can be animated and/or color-coded to indicate operation of the equipment.

GG. Graphic Sequence of Operation: It is a graphical representation of the sequence of operation, showing all inputs and output logical blocks.

HH. I/O Unit: The section of a digital control system through which information is received and transmitted. I/O refers to analog input

(AI, digital input (DI), analog output (AO) and digital output (DO). Analog signals are continuous and represent temperature, pressure, flow rate etc, whereas digital signals convert electronic signals to digital pulses (values), represent motor status, filter status, on-off equipment etc.

II. I/P: a method for conveying and routing packets of information over LAN paths. User Datagram Protocol (UDP) conveys information to “sockets” without confirmation of receipt. Transmission Control Protocol (TCP) establishes "sessions", which have end-to-end confirmation and guaranteed sequence of delivery.

JJ. JPEG: A standardized image compression mechanism stands for Joint Photographic Experts Group, the original name of the committee that wrote the standard.

KK. Local Area Network (LAN): A communication bus that interconnects operator workstation and digital controllers for peer-to-peer communications, sharing resources and exchanging information.

LL. Network Repeater: A device that receives data packet from one network and rebroadcasts to another network. No routing information is added to the protocol.

MM. MS/TP: Master-slave/token-passing (ISO/IEC 8802, Part 3).It uses twisted-pair wiring for relatively low speed and low cost communication.

NN. 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.

OO. 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.

PP. Object: The concept of organizing BACnet information into standard components with various associated properties. Examples include analog input objects and binary output objects.

QQ. Object Identifier: An object property used to identify the object, including object type and instance. Object Identifiers must be unique within a device.

RR. 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.

SS. Operating system (OS): Software, which controls the execution of computer application programs.

TT. 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.

UU. Peripheral: Different components that make the control system function as one unit. Peripherals include monitor, printer, and I/O unit.

VV. 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.

WW. PICS: Protocol Implementation Conformance Statement, describing the BACnet capabilities of a device. All BACnet devices have published PICS.

XX. PID: Proportional, integral, and derivative control, used to control modulating equipment to maintain a setpoint.

YY. Repeater: A network component that connects two or more physical segments at the physical layer.

ZZ. 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.

AAA. Sensors: devices measuring state points or flows, which are then transmitted back to the DDC system.

BBB. Thermostats : devices measuring temperatures, which are used in control of standalone or unitary systems and equipment not attached to the DDC system.

1.4 QUALITY ASSURANCE

A. Criteria:

1. Single Source Responsibility of subcontractor: Either the DDC Contractor or the System Integrator shall obtain hardware and software supplied under this Section and delegate the responsibility to a single source controls installation subcontractor. The

Integration subcontractor shall be responsible for the complete design, installation, integration, and commissioning of the system. The controls subcontractor shall be in the business of design, installation and service of such building automation control systems similar in size and complexity.

2. Equipment and Materials: Equipment and materials shall be cataloged products of manufacturers regularly engaged in production and installation of HVAC control systems. Products shall be manufacturer’s latest standard design and have been tested and proven in actual use.
3. The controls subcontractor shall provide a list of no less than five similar projects which have building control systems as specified in this Section. These projects must be on-line and functional such that the Department of Veterans Affairs (VA) representative could observe the control systems in full operation.
4. The controls subcontractor shall have an in-place facility within 50 miles with technical staff, spare parts inventory for the next five (5) years, and necessary test and diagnostic equipment to support the control systems.
5. The controls subcontractor shall have minimum of three years of experience in design and installation of building automation systems similar in performance to those specified in this Section. 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.
2. Graphic Refresh: The system shall update all dynamic points with current data within eight (8) seconds. Data refresh shall be automatic, without operator intervention.
3. Object Command: The maximum time between the command of a binary object by the operator and the reaction by the device shall be two(2) seconds. Analog objects shall start to adjust within two (2) seconds.
4. Object Scan: All changes of state and change of analog values shall be transmitted over the high-speed network such that any data used or displayed at a controller or work-station will be current, within the prior six (6) seconds.
5. Alarm Response Time: The maximum time from when an object goes into alarm to when it is annunciated at the workstation shall not exceed (10) seconds.
6. Program Execution Frequency: Custom and standard applications shall be capable of running as often as once every (5) seconds. The Contractor shall be responsible for selecting execution times consistent with the mechanical process under control.
7. Multiple Alarm Annunciations: All workstations on the network shall receive alarms within five (5) seconds of each other.
8. Performance: Programmable Controllers shall be able to execute DDC PID control loops at a selectable frequency from at least once every one (1) second. The controller shall scan and update the process value and output generated by this calculation at this same frequency.

9. Reporting Accuracy: Listed below are minimum acceptable reporting end-to-end accuracies for all values reported by the specified system:

Measured Variable	**Reported Accuracy**
Space temperature	±0.5°C (±1°F)
Ducted air temperature	±0.5°C [±1°F]
Outdoor air temperature	±1.0°C [±2°F]
Dew Point	±1.5°C [±3°F]
Water temperature	±0.5°C [±1°F]
Relative humidity	±2% RH
Water flow	±1% of reading
Air flow (terminal)	±10% of reading
Air flow (measuring stations)	±5% of reading
Carbon Monoxide (CO)	±5% of reading
Carbon Dioxide (CO_2)	±50 ppm
Air pressure (ducts)	±25 Pa [±0.1"w.c.]
Air pressure (space)	±0.3 Pa [±0.001"w.c.]
Water pressure	±2% of full scale *Note 1
Electrical Power	±0.5% of reading

Note 1: for both absolute and differential pressure

10. Control stability and accuracy: Control sequences shall maintain measured variable at setpoint within the following tolerances:

Controlled Variable	Control Accuracy	Range of Medium
Air Pressure	±50 Pa (±0.2 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	MRI, SPS, PHARMACY
Fluid Pressure	±10 kPa (±1.5 psi)	0–1 MPa (1–150 psi)
Fluid Pressure	±250 Pa (±1.0 in. w.g.)	0–12.5 kPa (0–50 in. w.g.) differential

11. Extent of direct digital control: control design shall allow for at least the points indicated on the points lists on the drawings.

1.6 WARRANTY

A. Labor and materials for control systems shall be warranted for a period as specified under Warranty in FAR clause 52.246-21.

B. Control system failures during the warranty period shall be adjusted, repaired, or replaced at no cost or reduction in service to the owner. The system includes all computer equipment, transmission equipment, and all sensors and control devices.

C. The on-line support service shall allow the Controls supplier to dial out over telephone lines to or connect via (through password-limited access) VPN through the internet to monitor and control the facility's building automation system. This remote connection to the facility shall be within two (2) hours of the time that the problem is reported. This coverage shall include normal business hours, after business hours, weekend and holidays. If the problem cannot be resolved with on-line support services, the Controls supplier shall dispatch the qualified personnel to the job site to resolve the problem within 8 hours after the problem is reported.

D. Controls subcontractor shall be responsible for temporary operations and maintenance of the control systems during the construction period until final commissioning, training of facility operators and acceptance of the project by VA.

1.7 SUBMITTALS

A. Submit shop drawings in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Manufacturer’s literature and data for all components including but not limited to 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 system and the associated control diagrams. Equipment and control labels shall correspond to those shown on the drawings.

7. Color prints of proposed graphics with a list of points for display.
8. Furnish a BACnet Protocol Implementation Conformance Statement (PICS) for each BACnet-compliant device.
9. Schematic wiring diagrams for all control, communication and power wiring. Provide a schematic drawing of the central system installation. Label all cables and ports with computer manufacturers' model numbers and functions. Show all interface wiring to the control system.
10. An instrumentation list for each controlled system. Each element of the controlled system shall be listed in table format. The table shall show element name, type of device, manufacturer, model number, and product data sheet number.
11. Riser diagrams of wiring between central control unit(CCU)and all control panels.
12. Plan drawings showing routing of LAN and locations of control panels, controllers, routers, gateways, ECC, and larger controlled devices.
13. Construction details for all installed conduit, cabling, raceway, cabinets, and similar. Construction details of all penetrations and their protection.
14. Quantities of submitted items may be reviewed but it is the responsibility of the contractor administered by this Section of the technical specifications to provide sufficient quantities for a complete and working system.

C. Product Certificates: Compliance with Article, QUALITY ASSURANCE.

D. Licenses: Provide licenses for all software residing on and used by the Controls Systems, ECC, and portable OWS and transfer these licenses to the Owner prior to completion.

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) set of applicable control system prints for each mechanical system for wall mounting. The documents shall be submitted for approval prior to final completion.

3. Furnish one (1) CD-ROM in CAD DWG and/or .DXF format for the drawings noted in subparagraphs above.

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 COR prior to final inspection.

1.8 INSTRUCTIONS

A. Instructions to VA operations personnel: Perform in accordance with Article, INSTRUCTIONS, in Specification Section 01 00 00, GENERAL REQUIREMENTS, and as noted below.

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 Controllers used outdoors shall be mounted in NEMA 4 waterproof enclosures and shall be rated for operation at –40 to 65°C (-40 to 150°F).
C. All electronic equipment shall operate properly with power fluctuations of plus 10 percent to minus 15 percent of nominal supply voltage.
D. Sensors and controlling devices shall be designed to operate in the environment, which they are sensing or controlling.

1.10 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):

135-2017................BACNET Building Automation and Control Networks

C. American Society of Mechanical Engineers (ASME):

B16.18-2018.............Cast Copper Alloy Solder Joint Pressure Fittings.
B16.22-2018.............Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.

D. American Society of Testing Materials (ASTM):

B32-2014................Standard Specification for Solder Metal
B88-2016................Standard Specifications for Seamless Copper Water Tube
B88M-2018...............Standard Specification for Seamless Copper Water Tube (Metric)
B280-2019...............Standard Specification for Seamless Copper Tube for Air-Conditioning and Refrigeration Field Service
D2737-2018..............Standard Specification for Polyethylene (PE) Plastic Tubing

E. Federal Communication Commission (FCC):

Rules and Regulations Title 47 Chapter 1-2014 Part 15: Radio Frequency Devices.

F. Institute of Electrical and Electronic Engineers (IEEE):

802.3-2018..............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):

70-2017.................National Electric Code
90A-2018................Standard for Installation of Air-Conditioning and Ventilation Systems

H. Underwriter Laboratories Inc (UL):

94-2013.................Tests for Flammability of Plastic Materials for Parts and Devices and Appliances
294-2013................Access Control System Units
486A/486B-2018..........Wire Connectors
555S-2014(R2016)........Standard for Smoke Dampers
916-2015................Energy Management Equipment
1076-2018...............Proprietary Burglar Alarm Units and Systems

PART 2 – PRODUCS

2.1 MATERIALS

A. Use new products that the manufacturer is currently manufacturing and that have been installed in a minimum of **25** installations. Spare parts shall be available for at least **five** years after completion of this contract.

2.2 CONTROLS SYSTEM ARCHITECTURE

A. General
   1. The Controls Systems shall consist of multiple Nodes and associated equipment connected by industry standard digital and communication network arrangements.
   2. The ECC, building controllers and principal communications network equipment shall be standard products of recognized major manufacturers available through normal PC and computer vendor channels – not "Clones" assembled by a third-party subcontractor.
   3. The networks shall, at minimum, comprise, as necessary, the following:
      a. A fixed ECC and a portable operator’s terminal.
      b. Network computer processing, data storage and BACnet-compliant communication equipment including Servers and digital data processors.
      c. BACnet-compliant routers, bridges, switches, hubs, modems, gateways, interfaces and similar communication equipment.
      d. Active processing BACnet-compliant building controllers connected to other BACNet-compliant controllers together with their power supplies and associated equipment.
      e. Addressable elements, sensors, transducers and end devices.
      f. Third-party equipment interfaces and gateways as described and required by the Contract Documents.
      g. Other components required for a complete and working Control Systems as specified.

B. The Specifications for the individual elements and component subsystems shall be minimum requirements and shall be augmented as necessary by the Contractor to achieve both compliance with all applicable codes, standards, and to meet all requirements of the Contract Documents.

C. Network Architecture

1. The Controls communication network shall utilize BACnet communications protocol operating over a standard Ethernet LAN and operate at a minimum speed of 100 Mb/sec.
2. The networks shall utilize only copper and optical fiber communication media as appropriate and shall comply with applicable codes, ordinances and regulations.
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.

E. Servers:

1. Provide data storage server(s) to archive historical data including trends, alarm and event histories and transaction logs.
2. Equip these server(s) with the same software tool set that is located in the BACnet building controllers for system configuration and custom logic definition and color graphic configuration.
3. Access to all information on the data storage server(s) shall be through the same browser functionality used to access individual nodes. When logged onto a server the operator will be able to also interact with any other controller on the control system as required for the functional operation of the controls systems. The contractor administered by this Section of the technical specifications shall provide all necessary digital processor programmable data storage server(s).
4. These server(s) shall be utilized for controls systems application configuration, for archiving, reporting and trending of data, for operator transaction archiving and reporting, for network

information management, for alarm annunciation, for operator interface tasks, for controls application management and similar.

5. These server(s) shall utilize IT industry standard data base platforms which utilize a database declarative language designed for managing data in relational database management systems (RDBMS) such as SQL.

2.3 COMMUNICATION

A. Control products, communication media, connectors, repeaters, hubs, and routers shall comprise a BACnet internetwork. Controller and operator interface communication shall conform to ANSI/ASHRAE Standard 135, BACnet.
    1. The Data link / physical layer protocol between the ECC and all B-BC’s (for communication) acceptable to the VA throughout its facilities is Ethernet (ISO 8802-3) and BACnet/IP.
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 internet 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 ENGINEERING CONTROL CENTER (ECC)

A. The ECC shall reside on a high-speed network with controllers as shown on system drawings. The ECC and each standard browser connected to server shall be able to access all system information.

B. ECC and controllers shall communicate using BACnet protocol. ECC and control network backbone shall communicate using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing as specified in ASHRAE/ANSI 135, BACnet Annex J.

C. Hardware: ECC shall conform to the BACnet Advanced Workstation (B-AWS) Profile and shall be BTL-Listed as a B-AWS device.

1. ECC shall be based on commercially available server grade hardware. Computers based on desktop architectures shall not be permitted. ECC shall have remote management capabilities.
2. Processor(s):
   a. Processors shall be either Intel Xeon or AMD EPYC chips sets designed specifically for server use. Desktop processors will not be allowed.
   b. Minimum core count shall be 16 cores. Each Core shall be capable of executing 2 threads simultaneously.

   Minimum base clock speed shall be 3.0 GHz
3. Memory:
   a. Engineering Control Center shall be equipped with a minimum of 32G of DDR4 Error Correcting Code (ECC) memory. After installation of required 32G of RAM, the motherboard must still have a minimum of 2 DIMM slots open for expansion. Motherboard shall be capable of minimum of 64GB of ECC memory.
   b. Minimum speed shall be 2133MHz for memory
4. Storage:
   a. ECC shall be equipped with a RAID capable drive controller capable of handling at least 8 internal, hot swappable drives.
   b. All installed drives shall be “Enterprise Class” drives designed specifically for server use.
   c. Minimum configuration shall consist of 6 drives in 2 separate RAID arrays:

1) The operating system shall be stored on a RAID 1 array compromising of 2 drives with each drive having a minimum capacity of 1TB each.
2 The B-AWS software and all its related databases shall be stored in RAID 5 array consisting of 4 drives with each drive have a minimum of 4TB capacity for a minimum storage capacity of 12TB's.
3) An alternative configuration for the 2 RAID arrays described above is 8 drives arrayed in a RAID 10 configuration. In this case the OS RAID array would consist of 4 drives of 1TB minimum each, and the B-AWS RAID array consisting of 4 drives of 16TB minimum each. This configuration would provide faster write times and much quicker rebuild times in the event of a drive failure.

d. ECC will include an 16X DVD R/W drive

5. Case:
   a. Case shall have space for a minimum of 8 hot swap 3.5" hard drives and one internal optical drive
   b. Real-time clock:
      1) Accuracy: Plus or minus 1 minute per month.
      2) Time Keeping Format:24-hour time format including seconds, minutes, hours, date, day, and month; automatic reset by software.
      3) Clock shall function for one year without power.
      4) Provide automatic time correction once every 24 hours by synchronizing clock with the Time Service Department of the U.S. Naval Observatory.
   c. Serial ports: Four USB ports and two RS-232-F serial ports for general use, with additional ports as required. Data transmission rates shall be selectable under program control.
   d. Parallel port: Enhanced.
   e. Sound card: For playback and recording of digital WAV sound files associated with audible warning and alarm functions.
   f. Color monitor: PC compatible, not less than 22 inches, LCD type, with a minimum resolution of 1280 by 1024 pixels, non-interlaced, and a maximum dot pitch of 0.28 mm.

g. Keyboard: Minimum of 64 characters, standard ASCII character set based on ANSI INCITS 154.
h. Mouse: Standard, compatible with installed software.
i. Removable disk storage: Include the following, each with appropriate controller:
    1) Minimum 1 TB removable hard disk, maximum average access time of 10 ms.
j. Network interface card (NIC): integrated 10-100-1000 Base-TX Ethernet NIC with an RJ45 connector or a 100Base-FX Ethernet NIC with an SC/ST connector.

6. Cable modem: 42.88 MBit/s, DOCSIS 2.0 Certified, also backwards compatible with DOCSIS 1.1/1.0 standards. Provide Ethernet or USB connectivity.
7. Optical modem: full duplex link, for use on 10 GBase-R single-mode and multi-mode fiber with a XENPAK module.
8. Auto-dial modem: 56,600 bps, full duplex for asynchronous communications. With error detection, auto answer/autodial, and call-in-progress detection. Modem shall comply with requirements in ITU-T v.34, ITU-T v.42, ITU-T v.42 Appendix VI for error correction, and ITU-T v.42 BIS for data compression standards; and shall be suitable for operating on unconditioned voice-grade telephone lines complying with 47 CFR 68.
9. Audible Alarm: Manufacturer's standard.
10. Printers:
    a. Provide a dedicated, minimum resolution 600 dpi, color laser printer, connected to the ECC through a USB interface.
        1) If a network printer is used instead of this dedicated printer, it shall have a 100Base-T interface with an RJ45 connection and shall have a firmware print spooler compatible with the Operating System print spooler.
        2) RAM: 512 MB, minimum.
        3) Printing Speed: Minimum twenty-six pages per minute (color); minimum 30 pages per minute (black/white).
        4) Paper Handling: Automatic sheet feeder with 250-sheet x 8.5 inch x 11 inch paper cassette and with automatic feed.

b. Provide a dedicated black/white tractor-feed dot matrix printer for status/alarm message printing, minimum 10 characters per inch, minimum 160 characters per second, connected to the ECC through a USB interface.
   1) Paper: One box of 2000 sheets of 8-1/2x11 multi-fold type printer paper.

11. RS-232 ASCII Interface
   a. ASCII interface shall allow RS-232 connections to be made between a meter or circuit monitor operating as the host PC and any equipment that will accept RS-232 ASCII command strings, such as local display panels, dial-up modems, and alarm transmitters.
   b. Pager System Interface: Alarms shall be able to activate a pager system with customized message for each input alarm.
   c. Alarm System Interface: RS-232 output shall be capable of transmitting alarms from other monitoring and alarm systems to workstation software.
   d. RS-232 output shall be capable of connection to a pager interface that can be used to call a paging system or service and send a signal to a portable pager. System shall allow an individual alphanumeric message per alarm input to be sent to paging system. This interface shall support both numeric and alphanumeric pagers.
   e. Cables: provide Plenum-Type, RS-232 Cable: Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, plastic insulation, and individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage; plastic jacket. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
      1) NFPA 70, Type CMP.
      2) Flame Resistance: NFPA 262, Flame Test.

12. Self-contained uninterruptible power supply (UPS):
   a. Size: Provide a minimum of six hours of operation of ECC equipment, including two hours of alarm printer operation.
   b. Batteries: Sealed, valve regulated, recombinant, lead calcium.
   c. Accessories:
      1) Transient voltage suppression.

2) Input-harmonics reduction.
3) Rectifier/charger.
4) Battery disconnect device.
5) Static bypass transfer switch.
6) Internal maintenance bypass/isolation switch.
7) External maintenance bypass/isolation switch.
8) Output isolation transformer.
9) Remote UPS monitoring.
10) Battery monitoring.
11) Remote battery monitoring.

D. ECC Software:

1. Provide for automatic system database save and restore on the ECC's hard disk a copy of the current database of each Controller. This database shall be updated whenever a change is made in any system panel. In the event of a database loss in a building management panel, the ECC shall automatically restore the database for that panel. This capability may be disabled by the operator.
2. Provide for manual database save and restore. An operator with proper clearance shall be able to save the database from any system panel. The operator also shall be able to clear a panel database and manually initiate a download of a specified database to any panel in the system.
3. Provide a method of configuring the system. This shall allow for future system changes or additions by users with proper clearance.
4. Operating System. Furnish a concurrent multi-tasking operating system. The operating system also shall support the use of other common software applications. Acceptable operating systems are Windows Server 2019, Linux, and UNIX.
5. System Graphics. The operator workstation software shall be graphically oriented. The system shall allow display of up to 10 graphic screens at once for comparison and monitoring of system status. Provide a method for the operator to easily move between graphic displays and change the size and location of graphic displays on the screen. The system graphics shall be able to be modified while on-line. An operator with the proper password level shall be able to add, delete, or change dynamic objects on a

graphic. Dynamic objects shall include analog and binary values, dynamic text, static text, and animation files. Graphics shall have the ability to show animation by shifting image files based on the status of the object.

6. Custom Graphics. Custom graphic files shall be created with the use of a graphics generation package furnished with the system. The graphics generation package shall be a graphically based system that uses the mouse to create and modify graphics that are saved in industry standard formats such as PCX, TIFF, and GEM. The graphics generation package also shall provide the capability of capturing or converting graphics from other programs such as Designer or AutoCAD.
7. Graphics Library. Furnish a complete library of standard HVAC equipment graphics such as chillers, boilers, air handlers, terminals, fan coils, and unit ventilators. This library also shall include standard symbols for other equipment including fans, pumps, coils, valves, piping, dampers, and ductwork. The library shall be furnished in a file format compatible with the graphics generation package program.
8. The Controls Systems Operator Interfaces shall be user friendly, readily understood and shall make maximum use of colors, graphics, icons, embedded images, animation, text based information and data visualization techniques to enhance and simplify the use and understanding of the displays by authorized users at the ECC. The operating system shall be Windows XP or better and shall support the third party software.
9. Provide graphical user software, which shall minimize the use of keyboard through the use of the mouse and "point and click" approach to menu selection.
10. The software shall provide a multi-tasking type environment that will allow the user to run several applications simultaneously. The mouse or Alt-Tab keys shall be used to quickly select and switch between multiple applications. The operator shall be able automatically export data to and work in Microsoft Word, Excel, and other Windows based software programs, while concurrently on-line system alarms and monitoring information.

11. On-Line Help. Provide a context-sensitive, on-line help system to assist the operator in operating and editing the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext.
12. User access shall be protected by a flexible and Owner re-definable software-based password access protection. Password protection shall be multi-level and partition able to accommodate the varied access requirements of the different user groups to which individual users may be assigned. Provide the means to define unique access privileges for each individual authorized user. Provide the means to on-line manage password access control under the control of a project specific Master Password. Provide an audit trail of all user activity on the Controls Systems including all actions and changes.
13. The system shall be completely field-programmable from the common operator's keyboard thus allowing hard disk storage of all data automatically. All programs for the CUs shall be able to be downloaded from the hard disk. The software shall provide the following functionality as a minimum:
    a. Point database editing, storage and downloading of controller databases.
    b. Scheduling and override of building environmental control systems.
    c. Collection and analysis of historical data.
    d. Alarm reporting, routing, messaging, and acknowledgement.
    e. Definition and construction of dynamic color graphic displays.
    f. Real-time graphical viewing and control of environment.
    g. Scheduling trend reports.
    h. Program editing.
    i. Operating activity log and system security.
    j. Transfer data to third party software.
14. Provide functionality such that using the least number of steps to initiate the desired event may perform any of the following simultaneously:
    a. Dynamic color graphics and graphic control.
    b. Alarm management.

c. Event scheduling.
d. Dynamic trend definition and presentation.
e. Program and database editing.
f. Each operator shall be required to log on to the system with a username and password to view, edit or delete the data. System security shall be selectable for each operator, and the password shall be able to restrict the operator’s access for viewing and changing the system programs. Each operator shall automatically be logged off the system if no keyboard or mouse activity is detected for a selected time.

15. Graphic Displays:
a. The workstation shall allow the operator to access various system schematics and floor plans via a graphical penetration scheme, menu selection, or text-based commands. Graphic software shall permit the importing of AutoCAD or scanned pictures in the industry standard format (such as PCX, BMP, GIF, and JPEG) for use in the system.
b. System Graphics shall be project specific and schematically correct for each system. (ie: coils, fans, dampers located per equipment supplied with project.) Standard system graphics that do not match equipment or system configurations are not acceptable. Operator shall have capability to manually operate the entire system from each graphic screen at the ECC. Each system graphic shall include a button/tab to a display of the applicable sequence of operation.
c. Dynamic temperature values, humidity values, flow rates, and status indication shall be shown in their locations and shall automatically update to represent current conditions without operator intervention and without pre-defined screen refresh values.
d. Color shall be used to indicate status and change in status of the equipment. The state colors shall be user definable.
e. A clipart library of HVAC equipment, such as chillers, boilers, air handling units, fans, terminal units, pumps, coils, standard ductwork, piping, valves and laboratory symbols shall be provided

in the system. The operator shall have the ability to add custom symbols to the clipart library.

f. A dynamic display of the site-specific architecture showing status of the controllers, the ECC and network shall be provided.
g. The windowing environment of the workstation shall allow the user to simultaneously view several applications at a time to analyze total building operation or to allow the display of graphic associated with an alarm to be viewed without interrupting work in progress. The graphic system software shall also have the capability to split screen, half portion of the screen with graphical representation and the other half with sequence of operation of the same HVAC system.

16. Trend reports shall be generated on demand or pre-defined schedule and directed to monitor display, printers or disk. As a minimum, the system shall allow the operator to easily obtain the following types of reports:
    a. A general list of all selected points in the network.
    b. List of all points in the alarm.
    c. List of all points in the override status.
    d. List of all disabled points.
    e. List of all points currently locked out.
    f. List of user accounts and password access levels.
    g. List of weekly schedules.
    h. List of holiday programming.
    i. List of limits and dead bands.
    j. Custom reports.
    k. System diagnostic reports, including, list of digital controllers on the network.
    l. List of programs.
17. Electrical, Gas, and Weather Reports
    a. Electrical Meter Report: Provide a monthly report showing the daily electrical consumption and peak electrical demand with time and date stamp for each building meter.
    b. Provide an annual (12-month) summary report showing the monthly electrical consumption and peak demand with time and date stamp for each meter.

c. Gas Meter Report: Provide a monthly report showing the daily natural gas consumption for each meter. Provide an annual (12-month) report that shows the monthly consumption for each meter.
d. Weather Data Report: Provide a monthly report showing the daily minimum, maximum, and average outdoor air temperature, as well as the number of heating and cooling degree-days for each day. Provide an annual (12-month) report showing the minimum, maximum, and average outdoor air temperature for the month, as well as the number of heating and cooling degree-days for the month.

18. Scheduling and Override:
    a. Provide override access through menu selection from the graphical interface and through a function key.
    b. Provide a calendar type format for time-of-day scheduling and overrides of building control systems. Schedules reside in the ECC. The digital controllers shall ensure equipment time scheduling when the ECC is off-line. The ECC shall not be required to execute time scheduling. Provide the following spreadsheet graphics as a minimum:
        1) Weekly schedules.
        2) Zone schedules, minimum of 100 zones.
        3) Scheduling up to 365 days in advance.
        4) Scheduled reports to print at workstation.
19. Collection and Analysis of Historical Data:
    a. Provide trending capabilities that will allow the operator to monitor and store records of system activity over an extended period. Points may be trended automatically on time-based intervals or change of value, both of which shall be user definable. The trend interval could be five (5) minutes to 120 hours. Trend data may be stored on hard disk for future diagnostic and reporting. Additionally, trend data may be archived to network drives or removable disk media for off-site retrieval.
    b. Reports may be customized to include individual points or predefined groups of at least six points. Provide additional functionality to allow pre-defined groups of up to 250 trended points to be easily accessible by other industry standard word

processing and spreadsheet packages. The reports shall be time and date stamped and shall contain a report title and the name of the facility.

c. System shall have the set up to generate spreadsheet reports to track energy usage and cost based on weekly or monthly interval, equipment run times, equipment efficiency, and/or building environmental conditions.

d. Provide additional functionality that will allow the operator to view real time trend data on trend graph displays. A minimum of 20 points may be graphed regardless of whether they have been predefined for trending. In addition, the user may pause the graph and take snapshots of the screens to be stored on the workstation disk for future reference and trend analysis. Exact point values may be viewed, and the graph may be printed. Operator shall be able to command points directly on the trend plot by double clicking on the point.

20. Alarm Management:

a. Alarm routing shall allow the operator to send alarm notification to selected printers or operator workstation based on time of day, alarm severity, or point type.

b. Alarm notification shall be provided via two alarm icons, to distinguish between routine, maintenance type alarms and critical alarms. The critical alarms shall display on the screen at the time of its occurrence, while others shall display by clicking on their icon.

c. Alarm display shall list the alarms with highest priority at the top of the display. The alarm display shall provide selector buttons for display of the associated point graphic and message in English language. The operator shall be able to sort out the alarms.

d. Alarm messages shall be customized for each point to display detailed instructions to the operator regarding actions to take in the event of an alarm.

e. An operator with proper security level access may acknowledge and clear the alarm. All that have not been cleared shall be archived at workstation disk.

21. Remote Communications: The system shall have the ability to dial out in the event of an alarm. Receivers shall include operator workstations, e-mail addresses, 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.
22. System Configuration:
    a. Network control strategies shall not be restricted to a single digital controller but shall be able to include data from all other network devices to allow the development of global control strategies.
    b. Provide automatic backup and restore of all digital controller databases on the workstation hard disk. In addition to all backup data, all databases shall be performed while the workstation is on-line without disturbing other system operations.

2.5 PORTABLE OPERATOR’S TERMINAL (POT)

A. Provide a portable operator’s terminal (POT) that shall be capable of accessing all system data. POT may be connected to any point on the system network or may be connected directly to any controller for programming, setup, and troubleshooting. POT shall communicate using BACnet protocol. POT may be connected to any point on the system network or it may be connected directly to controllers using the BACnet PTP (Point-To-Point) Data Link/ Physical layer protocol. The terminal shall use the Read (Initiate) and Write (Execute) BACnet Services. POT shall be an IBM-compatible notebook-style PC including all software and hardware required.

B. Hardware: POT shall conform to the BACnet Advanced Workstation (B-AWS) Profile and shall be BTL-Listed as a B-AWS device.
   1. POT shall be commercial standard with supporting 32- or 64-bit hardware (as limited by the direct-digital control system software) and software enterprise server. Internet Explorer v6.0 SP1 or higher, Windows Script Hosting version 5.6 or higher, Windows Message Queuing, Windows Internet Information Services (IIS) v5.0 or higher, minimum 2.8 GHz processor, minimum 500 GB 7200 rpm SATA hard drive with 16 MB cache, minimum 2GB DDR3 SDRAM (minimum 1333 Mhz) memory, 512 MB video card, minimum 16 inch (diagonal) screen, 10-100-1000 Base-TX Ethernet NIC with an RJ45 connector or a 100Base-FX

Ethernet NIC with an SC/ST connector, 56,600 bps modem, an ASCII RS-232 interface, and a 16 speed high density DVD-RW+/- optical drive.

C. Software: POT shall include software equal to the software on the ECC.

2.6 BACNET PROTOCOL ANALYZER

A. For ease of troubleshooting and maintenance, provide a BACnet protocol analyzer. Provide its associated fittings, cables and appurtenances, for connection to the communications network. The BACnet protocol analyzer shall be able to, at a minimum: capture and store to a file all data traffic on all network levels; measure bandwidth usage; filter out (ignore) selected traffic.

2.7 NETWORK AND DEVICE NAMING CONVENTION

A. Network Numbers

1. BACnet network numbers shall be based on a "facility code, network" concept. The "facility code" is the VAMC’s or VA campus’ assigned numeric value assigned to a specific facility or building. The "network" typically corresponds to a "floor" or other logical configuration within the building. BACnet allows 65535 network numbers per BACnet internet work.
2. The network numbers are thus formed as follows: "Net #" = "FFFNN" where:
   a. FFF = Facility code (see below)
   b. NN = 00-99 This allows up to 100 networks per facility or building

B. Device Instances

1. BACnet allows 4194305 unique device instances per BACnet internet work. Using Agency's unique device instances are formed as follows: "Dev #" = "FFFNNDD" where
   a. FFF and N are as above and
   b. DD = 00-99, this allows up to 100 devices per network.
2. Note Special cases, where the network architecture of limiting device numbering to DD causes excessive subnet works. The device number can be expanded to DDD and the network number N can become a single digit. In NO case shall the network number N and the device number D exceed 4 digits.
3. Facility code assignments:
4. 000-400 Building/facility number

5. Note that some facilities have a facility code with an alphabetic suffix to denote wings, related structures, etc. The suffix will be ignored. Network numbers for facility codes 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 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.

2.8 BACNET DEVICES

A. All BACnet Devices – controllers, gateways, routers, actuators, Operator Displays, and sensors shall conform to BACnet Device Profiles and shall be BACnet Testing Laboratories (BTL) -Listed as conforming to those Device Profiles. Protocol Implementation Conformance Statements (PICSs), describing the BACnet capabilities of the Devices shall be published and available for the Devices through links in the BTL website.

1. BACnet Building Controllers, shall conform to the BACnet B-BC Device Profile, and shall be BTL-Listed as conforming to the B-BC Device Profile. The Device's PICS shall be submitted.
2. BACnet Advanced Application Controllers shall conform to the BACnet B-AAC Device Profile and shall be BTL-Listed as conforming to the B-AAC Device Profile. The Device's PICS shall be submitted.

3. BACnet Application Specific Controllers shall conform to the BACnet B-ASC Device Profile and shall be BTL-Listed as conforming to the B-ASC Device Profile. The Device’s PICS shall be submitted.
4. BACnet Smart Actuators shall conform to the BACnet B-SA Device Profile and shall be BTL-Listed as conforming to the B-SA Device Profile. The Device’s PICS shall be submitted.
5. BACnet Smart Sensors shall conform to the BACnet B-SS Device Profile and shall be BTL-Listed as conforming to the B-SS Device Profile. The Device’s PICS shall be submitted.
6. BACnet routers and gateways shall conform to the BACnet B-OTH Device Profile, and shall be BTL-Listed as conforming to the B-OTH Device Profile. The Device’s PICS shall be submitted.

2.9 CONTROLLERS

A. General. Provide an adequate number of BTL listed B-BC building controllers, BTL listed B-AAC, BTL listed B-ASC, BTL listed B-SA, and BTL listed B-SS’s to achieve the performance specified in the Part 1 Article on “System Performance.” Each of these controllers shall meet the following requirements.
   1. Communication.
      a. Each B-BC controller shall reside on a BACnet network using the ISO 8802-3 (Ethernet) Data Link/Physical layer protocol for its communications.
      b. Each B-BC controller shall provide a service communication port using BACnet Data Link/Physical layer protocol for connection to a portable operator’s terminal. If this port is not available built into the controller, contractor is to install a 4 port unmanaged switch inside the B-BC control cabinet.
   2. Keypad. A local keypad and display shall be provided for each controller. The keypad shall be provided for interrogating and editing data. Provide a system security password shall be available to prevent unauthorized use of the keypad and display.
   3. Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.

4. Memory. The controller shall maintain all BIOS and programming information in the event of a power loss for at least 72 hours.
5. The controller shall be able to operate at 90% 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).
6. Transformer. Power supply for the ASC must be rated at a minimum of 125% of B-ASC power consumption and shall be of the fused or current limiting type.

B. Provide BTL-Listed B-ASC application specific controllers for each piece of equipment for which they are constructed. Application specific controllers shall communicate with other BACnet devices on the internetwork using the BACnet Read (Execute) Property service.
1. Each B-ASC shall be capable of stand-alone operation and shall continue to provide control functions without being connected to the network.
2. Each B-ASC will contain sufficient I/O capacity to control the target system.
3. Communication.
    a. Each controller shall reside on a BACnet network using the ISO 8802-3 (Ethernet) Data Link/Physical layer protocol for its communications. Each building controller also shall perform BACnet routing if connected to a network of custom application and application specific controllers.
    b. Each controller shall have a BACnet Data Link/Physical layer compatible connection for a laptop computer or a portable operator’s tool. This connection shall be extended to a space temperature sensor port where shown.
4. Serviceability. Provide diagnostic LEDs for power, communication, and processor. All wiring connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
5. Memory. The application specific controller shall use nonvolatile memory and maintain all BIOS and programming information in the event of a power loss.

6. Immunity to power and noise. Controllers shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80%. Operation shall be protected against electrical noise of 5-120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

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, Linuxor Microsoft Windows.
2. All points shall be identified by up to 30-character point name and 16-character point descriptor. The same names shall be used at the ECC.
3. All control functions shall execute within the stand-alone control units. All new controllers installed will also include all software and/or hardware required to program, commission, or alter the sequence of operation of said controller(s). Controllers requiring software or hardware that is not commercially available will not be allowed. Installation of software and/or hardware for controller configuration will be the responsibility of the DDC contractor. COR will direct to install said hardware and/or software on either the B-AWS or portable operator terminal. The VA shall be able to customize control strategies and sequences of operations defining the appropriate control loop algorithms and choosing the optimum loop parameters without requiring the services of a DDC contractor.
4. All controllers shall be capable of being programmed to utilize stored default values for assured fail-safe operation of critical processes. Default values shall be invoked upon sensor failure or, if the primary value is normally provided by the central or another CU, or by loss of bus communication. Individual application software packages shall be structured to assume a fail-safe condition upon loss of input sensors. Loss of an input sensor shall result in output of a sensor-failed message at the ECC. Each ACU and RCU shall have capability for local readouts of all functions. The UCUs shall be read remotely.
5. All DDC control loops shall be able to utilize any of the following control modes:

a. Two position (on-off, slow-fast) control.

b. Proportional control.

c. Proportional plus integral (PI) control.

d. Proportional plus integral plus derivative (PID) control. All PID programs shall automatically invoke integral wind up prevention routines whenever the controlled unit is off, under manual control of an automation system or time-initiated program.

e. Automatic tuning of control loops.

6. System Security: Operator access shall be secured using individual password and operator’s name. Passwords shall restrict the operator to the level of object, applications, and system functions assigned to him. A minimum of three (3)or a maximum of six (6) levels of security for operator access shall be provided.

7. Application Software: The controllers shall provide the following programs as a minimum for the purpose of optimizing energy consumption while maintaining comfortable environment for occupants. All application software shall reside and run in the system digital controllers. Editing of the application shall occur at the ECC or via a portable operator’s terminal, when it is necessary, to access directly the programmable unit.

a. 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 falls 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.

b. Night Setback/Morning Warm up Control: The system shall provide the ability to automatically adjust set points for this mode of operation.

c. 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.

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 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.

2.10 SPECIAL CONTROLLERS

A. Laboratory rooms and the fume hoods in those rooms shall be controlled to allow for a variable flow of conditioned air into the room, general exhaust from the room, and exhaust through the fume hood while maintaining a safe face velocity at the hood sash opening and proper space pressurization.

B. Fume Hood Exhaust Air Controller: The air flow through the open face of the hood, regardless of sash position, shall be controlled at a face velocity between 30 to 36 meter per minute (100 fpm and 120 fpm). A velocity sensor controller located in a sampling tube in the side wall of the hood shall control a damper in the hood discharge to maintain the face velocity.

C. Room Differential Pressure Controller: The differential pressure in laboratory rooms, operating rooms, in the SPS area, Chemo compounding rooms, and isolation rooms shall be maintained by controlling the quantity of air exhausted from or supplied to the room. A sensor-controller shall measure and control the velocity of air flowing into or out of the room through a sampling tube installed in the wall separating the room from the adjacent space and display the value on its monitor. The sensor-controller shall meet the following as a minimum:

1. Operating range: -0.25 to +0.25 inches of water column
2. Resolution: 5 percent of reading
3. Accuracy: +/- 10 percent of reading +/- 0.005 inches of water column
4. Analog output: 4-20 ma
5. Operating temperature range: 32°F-120°F

2.11 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 4-20 mA 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/heating coil face area.
   b. Immersion sensors shall be provided with a separable well made of stainless steel, bronze or monel material. Pressure rating of well is to be consistent with the system pressure in which it is to be installed. Temperature well shall be filled with a thermal compound compatible with installed sensor.
   c. All space sensors shall be equipped with in-space User set-point adjustment, override switch, numerical temperature display on sensor cover, and BACNet communication port. Match room thermostats. Provide a tooled-access cover.
      1) Public space sensor: setpoint adjustment shall be only through the ECC or through the DDC system's diagnostic device/laptop. Do not provide in-space User set-point adjustment. Provide an opaque keyed-entry cover if needed to restrict in-space User set-point adjustment.
   d. Outdoor air temperature sensors shall have watertight inlet fittings and be shielded from direct sunlight.

e. 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. Continuous Output Signal: 4-20 mA

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. Steam Flow Sensor/Transmitter:
1. Sensor: Vortex shedder incorporating wing type sensor and amplification technology for high signal-to-noise ratio, carbon steel body with 316 stainless steel working parts, 24 VDC power, NEMA 4 enclosure.
   a. Ambient conditions, -40°C to 80°C (-40°F to 175°F).
   b. Process conditions, 900 kPa (125 psig) saturated steam.
   c. Turn down ratio, 20 to 1.
   d. Output signal, 4-20 ma DC.
   e. Processor/Transmitter, NEMA 4 enclosure with keypad program selector and six digit LCD output display of instantaneous flow rate or totalized flow, solid state switch closure signal shall be provided to the nearest DDC panel for totalization.
      1) Ambient conditions, -20°C to 50°C (0°F-120°F), 0 95 percent non-condensing RH.
      2) Power supply, 120 VAC, 60 hertz or 24 VDC.
      3) Internal battery, provided for 24-month retention of RAM contents when all other power sources are removed.

f. Sensor on all steam lines shall be protected by pigtail siphons installed between the sensor and the line and shall have an isolation valve installed between the sensor and pressure source.

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.

2.12 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 electronic private branch exchange (EPBX) equipment the System may service.

4. The as-installed drawings shall identify each cable as labeled, used cable, and bad cable pairs.

5. Label system's cables on each end. Test and certify cables in writing to the VA before conducting proof-of-performance testing. Minimum cable test requirements are for impedance compliance, inductance, capacitance, signal level compliance, opens, shorts, cross talk, noise, and distortion, and split pairs on all cables in

the frequency ranges used. Make available all cable installation and test records at demonstration to the VA. All changes (used pair, failed pair, etc.) shall be posted in these records as the change occurs.

6. Power wiring shall not be run in conduit with communications trunk wiring or signal or control wiring operating at 100 volts or less.

B. Analogue control cabling shall be not less than No. 18 AWG solid or stranded, with thermoplastic insulated conductors as specified in Section 26 05 21.

C. Copper digital communication cable between the ECC and the B-BC and B-AAC controllers shall be 100BASE-TX Ethernet, Category 5e or 6, not less than minimum 24 American Wire Gauge (AWG) solid, Shielded Twisted Pair (STP) or Unshielded Twisted Pair (UTP), with thermoplastic insulated conductors, enclosed in a thermoplastic outer jacket, as specified in Section 27 15 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. All MS/TP communications cables for devices utilizing the EIA-485 standard must be listed for use on EIA-485 networks by the manufacturer of the cable. This requirement overrides any cable recommendation by the controller manufacturer. The use of EIA-485 communication cables shall not affect the warranty from the installing DDC contractor. Cables shall have the following characteristic:
   1. Nominal Impedance: 100-130 Ohms
   2. Twisted/shielded construction of 1, 1.5, or 2 pairs depending on controller requirements.
   3. Be plenum rated when required
   4. Cables designated for use by the cable manufacturer for use in PA or Speaker systems shall not be allowed, regardless of recommendations by the controller manufacturer.

E. Optical digital communication fiber, if used, shall be Multimode or 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.

2.13 THERMOSTATS AND HUMIDISTATS

A. Room thermostats controlling unitary standalone heating and cooling devices not connected to the DDC system shall have three modes of operation (heating - null or dead band - cooling). Thermostats for patient bedrooms shall have capability of being adjusted to eliminate null or dead band. Wall mounted thermostats shall have polished or brushed aluminum finish, setpoint range and temperature display and external adjustment:
   1. Electronic Thermostats: Solid-state, microprocessor based, 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. Patient Room Thermostats: thermistor with in-space User set point adjustment and an on-casing room temperature numerical temperature display.
      c. Psychiatric Patient Room Sensors: Electronic duct sensor as noted under Article 2.4.
      d. 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.

2.14 FINAL CONTROL ELEMENTS AND OPERATORS

A. Fail Safe Operation: Control valves and dampers shall provide "fail safe" operation in either the normally open or normally closed position as required for freeze, moisture, and smoke or fire protection.

B. Spring Ranges: Range as required for system sequencing and to provide tight shut-off.

C. Power Operated Control Dampers (other than VAV Boxes): Factory fabricated, balanced type dampers. All modulating dampers shall be opposed blade type and gasketed. Blades for two-position, duct-mounted dampers shall be parallel, airfoil (streamlined) type for minimum noise generation and pressure drop.

1. Leakage: 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.
5. Flow characteristics:
   a. Three way modulating valves shall be globe pattern. Position versus flow relation shall be linear relation for steam or equal percentage for water flow control.
   b. Two-way modulating valves shall be globe pattern. Position versus flow relation shall be linear for steam and equal percentage for water flow control.
   c. Two-way 2-position valves shall be ball, gate or butterfly type.
6. Maximum pressure drop:
   a. Two position steam control: 20 percent of inlet gauge pressure.
   b. Modulating Steam Control: 80 percent of inlet gauge pressure (acoustic velocity limitation).
   c. Modulating water flow control, greater of 3 meters (10 feet) of water or the pressure drop through the apparatus.
7. Two position water valves shall be line size.

F. Damper and Valve Operators and Relays:
1. Electric operator shall provide full modulating control of dampers and valves. For dampers a linkage and pushrod shall be furnished for mounting the actuator on the damper frame internally in the duct, externally in the duct, externally on the duct wall, or shall be furnished with a direct-coupled design. Metal parts shall be aluminum, mill finish galvanized steel, or zinc plated steel or stainless steel. Provide actuator heads which allow for electrical conduit attachment. The motor(s) shall have sufficient closure torque to allow for complete closure of valve or damper under pressure. Provide multiple motors as required to achieve sufficient close-off torque.
   a. Minimum valve close-off pressure shall be equal to the system pump’s dead-head pressure, minimum 50 psig for valves smaller than 4 inches.

3. Electronic damper operators: Metal parts shall be aluminum, mill finish galvanized steel, or zinc plated steel or stainless steel. Provide actuator heads which allow for electrical conduit attachment. The motors shall have sufficient closure torque to allow for complete closure of valve or damper under pressure. Provide multiple motors as required to achieve sufficient close-off torque.
   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.
4. See and coordinate drawings for required control operation.

2.15 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. 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 /required input pressure:
   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 or main 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 Control Unit (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.

C. Constant Volume Control Systems shall consist of an air flow measuring station along with such relays and auxiliary devices as required to produce a complete functional system. The transmitter shall receive its air flow signal or static pressure signal from the flow measuring station and shall have a span not exceeding three times the design flow rate. The CU shall receive the transmitter signal and shall provide an output to the fan volume control device to maintain a constant flow rate. The CU shall provide proportional plus integral (PI) (automatic reset) control mode and where required also inverse derivative mode. Overall system accuracy shall be plus or minus the equivalent of 2 Pascal (0.008 inch) velocity pressure as measured by the flow station.

D. Airflow Synchronization:

1. Systems shall consist of an air flow measuring station for each main 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 ±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.
2. 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.

2.16 SAFETY

A. Provide hard-wired interlocked connections for such all safety devices, such as freeze stats, smoke detectors, smoke dampers, and refrigerant leak detection devices. All safety devises shall be provided with additional dry contacts and shall be connected to the DDC system for monitoring and sequencing.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General:
   1. Examine project plans for control devices and equipment locations; and report any discrepancies, conflicts, or omissions to COR for resolution before proceeding for installation.
   2. Install equipment, piping, wiring /conduit parallel to or at right angles to building lines.
   3. Install all equipment and piping in readily accessible locations. Do not run tubing and conduit concealed under insulation or inside ducts.
   4. Mount control devices, tubing and conduit located on ducts and apparatus with external insulation on standoff support to avoid interference with insulation.
   5. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.
   6. Run tubing and wire connecting devices on or in control cabinets parallel with the sides of the cabinet neatly racked to permit tracing.
   7. Install equipment level and plumb.

B. Electrical Wiring Installation:
   1. All wiring and cabling shall be installed in conduits. Install conduits and wiring in accordance with Specification Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS. Conduits carrying control wiring and cabling shall be dedicated to the control wiring and cabling: these conduits shall not carry power wiring. Provide plastic end sleeves at all conduit terminations to protect wiring from burrs.
   2. Install analog signal and communication cables in conduit and in accordance with Specification Division 27 – COMMINICATIONS. Install

digital communication cables in conduit and in accordance with Specification Section 27 15 00, COMMINICATIONS STRUCTURED CABLING.

3. Install conduit and wiring between operator workstation(s), digital controllers, electrical panels, indicating devices, instrumentation, miscellaneous alarm points, thermostats, and relays as shown on the drawings or as required under this section.
4. Install all electrical work required for a fully functional system and not shown on electrical plans or required by electrical specifications. Where low voltage (less than 50 volt) power is required, provide suitable Class B transformers.
5. Install all system components in accordance with local Building Code and National Electric Code.
    a. Splices: Splices in shielded and coaxial cables shall consist of terminations and the use of shielded cable couplers. Terminations shall be in accessible locations. Cables shall be harnessed with cable ties.
    b. Equipment: Fit all equipment contained in cabinets or panels with service loops, each loop being at least 300 mm (12 inches) long. Equipment for fiber optics system shall be rack mounted, as applicable, in ventilated, self-supporting, code gauge steel enclosure. Cables shall be supported for minimum sag.
    c. Cable Runs: Keep cable runs as short as possible. Allow extra length for connecting to the terminal board. Do not bend flexible coaxial cables in a radius less than ten times the cable outside diameter.
    d. Use vinyl tape, sleeves, or grommets to protect cables from vibration at points where they pass around sharp corners, through walls, panel cabinets, etc.
6. Conceal cables, except in mechanical rooms and areas where other conduits and piping are exposed.
7. Permanently label or code each point of all field terminal strips to show the instrument or item served. Color-coded cable with cable diagrams may be used to accomplish cable identification.
8. Grounding: ground electrical systems per manufacturer’s written requirements for proper and safe operation.

C. Install Sensors and Controls:

1. Temperature Sensors:
   a. Install all sensors and instrumentation according to manufacturer’s written instructions. Temperature sensor locations shall be readily accessible, permitting quick replacement and servicing of them without special skills and tools.
   b. Calibrate sensors to accuracy specified, if not factory calibrated.
   c. Use of sensors shall be limited to its duty, e.g., duct sensor shall not be used in lieu of room sensor.
   d. Install room sensors permanently supported on wall frame. They shall be mounted at 1.5 meter (5.0 feet) above the finished floor unless otherwise noted on the plans or drawings.
   e. Mount sensors rigidly and adequately for the environment within which the sensor operates. Separate extended-bulb sensors form contact with metal casings and coils using insulated standoffs.
   f. Sensors used in mixing plenum, and hot and cold decks shall be of the averaging of type. Averaging sensors shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip.
   g. All pipe mounted temperature sensors shall be installed in wells.
   h. All wires attached to sensors shall be air sealed in their conduits or in the wall to stop air transmitted from other areas affecting sensor reading.
   i. Permanently mark terminal blocks for identification. Protect all circuits to avoid interruption of service due to short-circuiting or other conditions. Line-protect all wiring that comes from external sources to the site from lightning and static electricity.
2. Pressure Sensors:
   a. Install duct static pressure sensor tips facing directly downstream of airflow.
   b. Install high-pressure side of the differential switch between the pump discharge and the check valve.
   c. Install snubbers and isolation valves on steam pressure sensing devices.
3. Actuators:

a. Mount and link damper and valve actuators according to manufacturer’s written instructions.
b. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed position.
c. Check operation of valve/actuator combination to confirm that actuator modulates valve smoothly in both open and closed position.

4. Flow Switches:
   a. Install flow 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, chiller, pumping unit etc. Points used for control loop reset such as outdoor air, outdoor humidity, or space temperature could be located on any of the remote control units.

2. Provide sufficient internal memory for the specified control sequences and trend logging. There shall be a minimum of 25 percent of available memory free for future use.
3. System point names shall be human readable, permitting easy operator interface without the use of a written point index.
4. Provide software programming for the applications intended for the systems specified, and adhere to the strategy algorithms provided.
5. Provide graphics for each piece of equipment and floor plan in the building. This includes each chiller, cooling tower, air handling unit, fan, terminal unit, boiler, pumping unit etc. These graphics shall show all points dynamically as specified in the point list.

3.2 SYSTEM VALIDATION AND DEMONSTRATION

A. As part of final system acceptance, a system demonstration is required (see below). Prior to start of this demonstration, the contractor is to perform a complete validation of all aspects of the controls and instrumentation system.

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 ensure that system performs in accordance with approved

specifications and sequences of operation submitted. Installer shall complete and submit Test Check List.

C. Demonstration

1. System operation and calibration to be demonstrated by the installer in the presence of the Architect, Cx Agent or COR on random samples of equipment as dictated by the COR. Should random sampling indicate improper work, the owner reserves the right to subsequently witness complete calibration of the system at no addition cost to the VA.
2. Demonstrate to authorities that all required safeties and life safety functions are fully functional and complete. PG-18-10 Safety DM
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.

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(s). Control loop trend data shall be instantaneous and the time between data points shall not be greater than one (1) minute.

3.3 STARTUP AND TESTING

A. Perform tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.
B. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.
C. The 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 notice of 10 working days prior to startup and testing.

3.4 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

3.5 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer’s technical representative for 4 to instruct each VA personnel responsible in the operation and maintenance of the system.
B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

3.6 CONSTRUCTION WASTE MANAGEMENT

A. General: Comply with Contractor’s Waste Management Plan and Section 01 74 19, CONSTRUCTION WASTE MANAGEMENT.
B. To the greatest extent possible, separate reusable and recyclable products from contaminated waste and debris in accordance with the Contractor’s Waste Management Plan. Place recyclable and reusable products in designated containers and protect from moisture and contamination.

----- END -----

SECTION 23 10 00
FACILITY FUEL OIL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Diesel fuel oil and unheated burner fuel oil tanks, piping, and accessories located outside, underground or aboveground as shown on contract drawings. Refer to contract drawings for type of fuel and for tank capacities.

B. Tank fluid level monitoring and alarm systems.

C. Leak detection system for tanks and underground piping.

D. Fuel oil quality maintenance system (water and particulate removal).

E. A complete listing of common acronyms and abbreviations are included in Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

D. Section 03 30 00, CAST-IN-PLACE CONCRETE.

E. Section 05 50 00, METAL FABRICATIONS.

F. Section 09 91 00, PAINTING.

G. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

H. Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION.

I. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

J. Section 23 07 11, HVAC AND BOILER PLANT INSULATION.

K. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

L. Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.

M. Section 23 21 11, BOILER PLANT PIPING SYSTEMS.

N. Section 23 50 11, BOILER PLANT MECHANICAL EQUIPMENT.

O. Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION.

P. Section 31 20 00, EARTHWORK.

1.3 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Where conflicts occur these specifications and the VHA standard will govern.

B. American Petroleum Institute (API):

RP 1631-2001............Interior Lining and Periodic Inspection of Underground Storage Tanks

C. American Society of Mechanical Engineers (ASME):

B16.5-2017..............Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard.

B16.9-2018..............Factory Made Wrought Buttwelding Fittings

B16.11-2016.............Forged Fittings, Socket-Welding and Threaded

B31.1-2018..............Power Piping

D. American Society for Testing and Materials (ASTM):

A36/A36M-2017...........Standard Specification for Carbon Structural Steel

A53/A53M-2018...........Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

A105/A105M-2014.........Standard Specification for Carbon Steel Forgings for Piping Applications

A106/A106M-2015.........Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service

A126-04(R2019)..........Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings

A234/A234M-2015.........Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service

B62-2017................Standard Specification for Composition Bronze or Ounce Metal Castings

D2996-2015..............Standard Specification for Filament-Wound “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe

E. Federal Specifications (Fed. Spec.):

A-A-60005-1998..........Frames, Covers, Grating, Steps, Sump and Catch Basin, Manhole

F. NACE International (NACE):

SP0169-2013............Control of External Corrosion on Underground or Submerged Metallic Piping Systems

3/SSPC–SP6 2013.........Commercial Blast Cleaning

4/SSPC-SP7 2006........Brush-off Blast Cleaning

G. National Electrical Manufacturers Association (NEMA):

250-2014................Enclosures for Electrical Equipment (1000 Volts Maximum)

H. National Fire Protection Association (NFPA):

30-2018.................Flammable and Combustible Liquids Code

31-2019.................Standard for the Installation of Oil-Burning Equipment

70-2017.................National Electrical Code (NEC)

I. Steel Tank Institute (STI):

J. Underwriters Laboratories Inc. (UL):

142-2019................Standard for Steel Aboveground Tanks for Flammable and Combustible Liquids

2085-2019...............Standard for Protected Aboveground Tanks for Flammable and Combustible Liquids

1.4 SUBMITTALS

A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Information and material submitted under this section shall be marked “SUBMITTED UNDER SECTION 23 10 00, FACILITY FUEL OIL SYSTEMS”, with applicable paragraph identification.

C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.

D. Fuel Piping:

1. ASTM and UL compliance.
2. Grade, class or type, schedule number.
3. Manufacturer.

E. Pipe Fittings, Unions, Flanges:

1. ASTM and UL compliance.

2. ASTM standards number.
3. Catalog cuts.
4. Pressure and temperature rating.

F. Foot Valves, Check Valves, Overfill Prevention Valves:
1. Catalog cuts showing design and construction.
2. Pressure and temperature ratings.
3. Pressure loss and flow rate data.
4. Materials of construction.
5. Accessories.

G. Secondary Containment System for Fuel Piping:
1. Sizes, materials, construction of containment system including end seals, sumps, coatings and pipe supports.
2. Layout of system.
3. Installation instructions.
4. Design of cathodic protection system (steel casing).

H. Leak Detection System:
1. Drawings, description and performance data on sensors, control units.
2. Description of operation.
3. Layout of system.
4. Installation and operating instructions.
5. Data on interconnecting wiring systems to be furnished.

I. Tank Fluid Level Monitoring Instrumentation System:
1. Drawings showing instruments and in-tank sensing units, with dimensions.
2. Design and construction of all elements of system.
3. Installation instructions.

J. Tank and Piping Accessories: Design, construction, and dimensions of vent caps, fill boxes, fill caps, spill containers and other accessories.

K. Fuel Quality Maintenance System:
1. Drawings and description of all components and arrangement of system.
2. Design and performance of pumps, filters.
3. Catalog data and operation of control system.
4. Installation instructions.

L. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replacement parts, and troubleshooting guide:
   1. Include complete list indicating all components of the systems.
   2. Include complete diagrams of the internal wiring for each item of equipment.
   3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

M. Completed System Readiness Checklist provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

N. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

1.5 QUALITY ASSURANCE

A. Approval by Contracting Officer is required of products or services of proposed manufacturers, suppliers and installers, and will be based on Contractor’s certification that:
   1. Manufacturers regularly and currently manufacture tanks, tank and piping accessories, tank fluid level monitoring and leak detection systems, and fuel quality management systems.
   2. Manufacturers of steel tanks participate in the Quality Assurance Program of the Steel Tank Institute (STI).
   3. The design and size of each item of equipment provided for this project is of current production and has been in satisfactory operation on at least three installations for approximately three years. Current models of fluid level and leak detection systems with less than three years’ service experience are acceptable if similar previous models from the same manufacturer have at least three years’ service experience.

B. Apply and install materials, equipment and specialties in accordance with manufacturer’s written instructions. Conflicts between the manufacturer’s instructions and the contract drawings and specifications shall be referred to the COR for resolution. Provide copies of installation instructions to the COR two weeks prior to commencing installation of any item.

C. All equipment shall be free from defects that would adversely affect the performance, maintainability and appearance of individual components or overall assembly.

D. Tanks, Secondary Containment Systems for Piping, Plastic Piping and Containment Systems, Tank Level Monitoring Systems, Leak Detection Systems, Fuel Quality Management Systems, Cathodic Protection Systems: Authorized manufacturer’s representatives shall provide onsite training of installers and supervision of the installation and testing of the equipment and systems to assure conformance to written instructions of manufacturers.

E. Tank and piping installation contractor shall be certified as acceptable by local and state pollution control authorities.

F. Entire installation shall conform to requirements of local and state pollution control authorities.

G. Pipe Welding: Conform to requirements of ASME B31.1. Welders shall show evidence of qualification. Welders shall utilize a stamp to identify their work. Unqualified personnel will be rejected.

H. Assembly of Glass Fiber Reinforced Plastic Piping: Installation personnel shall have been trained, tested and certified under a procedure approved by the manufacturer of the piping. Proof of certification, in writing, shall be provided to the COR.

I. Where specified codes or standards conflict, consult the COR.

J. Label of Conformance (definition): Labels of accredited testing laboratories showing conformance to the standards specified.

K. Equipment and materials installed shall be compatible in all respects with other items being furnished and with existing items so that the result will be a safe, complete and fully operational system which conforms to contract requirements and in which no item is subject to conditions beyond its design capabilities.

1.6 AS-BUILT DOCUMENTATION

A. Submit manufacturer’s literature and data updated to include submittal review comments and any equipment substitutions.

B. Submit operation and maintenance data updated to include submittal review comments, VA approved substitutions and construction revisions shall be in electronic version on CD or DVD inserted into a three-ring binder. All aspects of system operation and maintenance procedures, including applicable piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices shall be included. A List of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.

C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the ‘third party testing company’ requirement. Provide record drawings as follows:
   1. As-built drawings are to be provided, with a copy of them on AutoCAD provided on CD or DVD. The CAD drawings shall use multiple line layers with a separate individual layer for each system.

D. The as-built drawings shall indicate the location and type of all lockout/tagout points for all energy sources for all equipment and pumps to include breaker location and numbers, valve tag numbers, etc. Coordinate lockout/tagout procedures and practices with local VA requirements.

E. Certification documentation shall be provided to COR 21 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and provide documentation/certification that all results of tests were within limits specified. Test results shall contain written sequence of test procedure with written test results annotated at each step along with the expected outcome or setpoint. The results shall include all readings, including but not limited to data on device (make, model and performance characteristics), normal pressures, switch ranges, trip points, amp readings, and calibration data to include equipment serial numbers or individual identifications, etc.

1.7 PERMITS

A. Contractor shall obtain and complete all tank permit and registration forms required by governmental authorities.

PART 2 - PRODUCTS

2.1 ABOVEGROUND STEEL TANKS

A. Type: Factory-fabricated all welded steel, horizontal cylindrical configuration, atmospheric pressure, internal and external corrosion protection as specified. In addition to specified requirements, tanks shall be fabricated in accordance with Steel Tank Institute (STI) design standards by manufacturer that participates in STI Quality Assurance Program.

B. Construction:

1. ASTM A36/A36M steel, conform to UL 142. Inner and outer tanks of double wall tanks shall both conform. Provide label of conformance.
2. Conform to NFPA 30 or NFPA 31 as applicable.
3. Double-wall, un-insulated, conforming to STI F001 “Flameshield” construction. Provide label of conformance.
4. Steel dike walls and floors conforming to STI standards. Provide minimum containment of 110 percent of primary tank contents.
5. Design for surcharge load produced by tank-mounted platforms and platform loadings shown. Design tanks for saddle supports furnished by tank manufacturer.
6. Leaks and abrasions are prohibited. Maximum permissible out-of-roundness of cylindrical shells is one percent of the diameter.
7. Provide lifting lugs for rigging tanks.
8. Make provisions for leak detectors to be installed at lowest part of interstitial space between walls of double-wall tanks.

C. Factory Cleaning: Clean interior and exterior of tanks and steel dikes (if furnished). Remove mill scale, dirt, rust, oil, welding debris, loose coatings and coatings incompatible with fuel stored or protective coating. Sandblast exterior in accordance with NACE 3.

D. Factory Coating: Provide tanks and steel dikes (if furnished) with exterior coat of rust resistant metal primer, specified under Section 09 91 00, PAINTING. Coat interior from bottom of tank to 1 m (3 feet) above bottom in compliance with API RP 1631.

E. Field Painting: Clean and coat all surfaces as specified in Section 09 91 00, PAINTING.

F. Pipe Connections to Tanks:

1. Conform to UL 142.
2. Pipe sizes 50 mm (2 inches) and smaller, threaded. Pipe sizes 65 mm (2-1/2 inches) and larger, flanged, 1034 kPa (150 psig) ASME rating.
3. Welded joints required on steel piping located inside tanks.
4. Provide and coordinate tank connection quantities, sizes and types with requirements of tank level gauge unit; sounding rod; vent, fill, supply and return pipes; and other pipes as shown.
5. On double-wall tanks, provide valved drain of interstitial space.

G. Tank Manholes: Provide quantity shown. Bolted cover type, gasketed.

H. Internal Ladder: Provide as shown with 50 mm x 6 mm (2 inch x 1/4 inch) sides and 20 mm (3/4 inch) diameter rungs at 300 mm (12 inches) on center. Provide slide supports to allow for tank movement.

I. Wear (Striker) Plates: Provide 300 mm (12 inch) square, 6 mm (1/4 inch) thick steel plates welded to tank bottom directly under the sounding opening, the fuel return discharge, and the fill discharge.

J. Lifting Lugs: Provide for rigging tanks.

K. Emergency Relief Vents for Fire Exposure: Venting capacity shall conform to NFPA 30 or NFPA 31 as applicable. Standard product of a manufacturer, designed to automatically open at tank pressure of 17 kPa (2.5 psig) gauge. Aluminum or cast-iron construction with Teflon seating surface. Provide separate vents for primary and secondary tanks.

L. Provide fittings for grounding per NFPA 70.

M. Seismic Design: Refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

2.2 TANK AND PIPING ACCESSORIES

A. Vent Caps: Galvanized cast iron or cast aluminum with brass or bronze screens, arranged to permit full venting and to prevent entry of foreign material into the vent line. Same pipe size as vent pipe.

B. Fill Boxes:
   1. Spill-container type enclosing a fill cap assembly with camlock hose connector with closure coordinated with fittings used by fuel supplier.
   2. Watertight assembly, cylindrical body, quick-opening corrosion-resistant watertight sealable cover, polyethylene spill containment compartment with minimum 5 gallon capacity. Integral drain valve with discharge to fill pipe.
   3. Fill cap shall be lockable, tight-fill design with provision for padlock on the top of the cap. Fill cap shall screw onto threaded adapter that can be removed without removing fill box. Entire assembly shall seal tight with no leakage during filling and when cap is in place.
   4. Provide special tools necessary for opening fill boxes and fill caps.
   5. Protect spill container from traffic by ramped, drain-slotted cast iron body ring and cover. Design shall prevent transmission of traffic loads to the underground tank. Spill-container type not required at locations designated only for sounding tanks.

C. Fill caps located above grade without fill boxes shall be lockable, tight-fill design, operated by special wrench that shall be furnished. Entire assembly shall seal tight with no leakage during fill and when cap is in place.

D. Refer to Section 05 50 00, METAL FABRICATIONS, for access platforms shown for aboveground tanks.

E. Support horizontal portion of pipes located inside tank every 2100 mm (7 feet) maximum.

F. Furnish gauging chart, liters versus mm and gallons versus inches depth.

G. Furnish sounding rod for each tank size. Mark rods in increments representing five percent of tank capacity. Provide length of rod suitable for tank burial depth (if applicable). Rods shall be graduated in gallons.

H. Fill Point Identification:

1. Fill Boxes at Grade Level: Aluminum, brass or bronze plate, anchored to concrete fill box pad with stamped or engraved letters 20 mm (3/4 inch) high.
2. Fill Caps above Grade: Aluminum, brass or bronze plate, clamped to fill pipe, with stamped or engraved letters 20 mm (3/4 inch) high.
3. Legend: "BURNER FUEL OIL FILL" "DIESEL FUEL FILL” or "SOUNDING" as appropriate.

2.3 PIPING, VALVES, FITTINGS

A. Fuel supply and return, tank fill, vents, sounding, and pump out.

B. Steel Pipe and Fittings:

1. Piping: Steel, seamless or electric resistance welded (ERW), ASTM A53/A53M Grade B or ASTM A106/A106M Grade B, Schedule 40. Aboveground piping shall be painted. Refer to Section 09 91 00, PAINTING.
2. Joints: Socket or butt-welded. Threaded joints are prohibited except at valves, unions, and tank connections.
3. Fittings:
   a. Butt-welded joints: Steel, ASTM A234/A234M, Grade B, ASME B16.9, same schedule as adjoining pipe.
   b. Socket-welded joints: Forged steel, ASME B16.11, 13,790 kPa (2000 psig) class.
4. Unions: Malleable iron, 2070 kPa (300 psig) class.
5. Companion flanges: Flanges and bolting, ASME B16.5.
6. Welding flanges: Weld neck, ASME B16.5, forged steel ASTM A105/A105M, 1034 kPa (150 psig).

C. Glass Fiber Reinforced Plastic (FRP) Pipe and Fittings:

1. Conform to UL 971 and ASTM D2996 using a filament-winding process and epoxy or vinyl ester resins.
2. Design pipe, fittings and joining system for required fuel service, 65 degrees C (150 degrees F), 1034 kPa (150 psig) pressure, 68 kPa (20 inches Hg) vacuum.
3. Provide an integral resin-rich liner, 0.5 mm (0.020 inches) minimum thickness to enhance the corrosion resistance. Outer layer shall include ultra-violet inhibitors. Joining adhesive shall be designed

for the pipe furnished and shall be supplied by the pipe manufacturer.

4. Plastic piping allowed in underground use only.

D. Check Valves - Fuel Pump Suction.

1. Pipe Sizes 50 mm (2 inches) and under: Rated for 1375 kPa (200 psig) water-oil-gas, swing-type, threaded ends, ASTM B62 bronze body. Provide union adjacent to valve.
2. Pipe Sizes 65 mm (2-1/2 inches) and above: Rated for 1380 kPa (200 psig) water-oil-gas, swing-type, 861 kPa (125 pounds) ASME flanged ends, ASTM A126 class B cast iron body.

E. Foot Valves - Fuel Pump Suction: Double poppet, lapped-in metal-to-metal seats, double-guided stems, 20 mesh inlet screen, same size as fuel suction piping. Foot valve shall be removable to above grade through the tank manhole enclosure or through extractor fitting.

F. Extractor Fittings: Arranged to permit removal of foot valves, overfill prevention valves, and other devices that are located below grade. Access point shall be through a cast iron fill box-type manhole located at grade. Provide extractor wrench.

G. Overfill Prevention Valve: Aluminum automatic valve designed for underground or aboveground tanks, as applicable. Removable through the extractor fitting on underground tanks. Locate valve near the top of the tank in the fill pipe. On underground tanks with gravity fill, provide two stage automatic float-operated valve. First stage operation at 92 percent tank capacity shall reduce flow to 0.3 L/s (5 gpm) or less. Second stage operation shall stop flow completely when tank is no more than 95 percent full. On aboveground tanks, or tanks pressure-filled, provide single stage valve, rated for fill flow and pressure, which stops flow completely at 95 percent of tank capacity. Valve shall include method for draining oil trapped above the valve into the tank.

2.4 SECONDARY CONTAINMENT FOR UNDERGROUND FUEL PIPING SYSTEMS

A. Enclose the fuel supply, return and fill pipes in factory-engineered and fabricated secondary containment conduit systems. The systems shall be complete with end seals, with 25 mm (1 inches) minimum continuous annular space, 40 mm (1-1/2 inches) between carrier pipes, which shall contain all leakage and which has provisions for leak detection system as specified.

B. Steel Conduit with Fusion-Bonded Epoxy Coating and Cathodic Protection:
   1. Galvanized carbon steel pipe, ASTM A53/A53M, Grade B, Schedule 40 for diameters through 125 mm (5 inches), 3.4 mm (0.134 inch) thick for diameters greater than 125 mm (5 inches) up through 660 mm (26 inches). All welded construction.
   2. Sand blast exterior per NACE 3.
   3. Coat exterior with 0.5 mm (20 mils) thick fusion-bonded epoxy.
   4. Provide cathodic protection designed by corrosion specialist and consisting of galvanic anodes, test stations, interconnecting wiring in conformance with UL 1746 and NACE SP0169. Electrical isolation required between all connecting systems in manholes and buildings.
C. Steel Conduit with Fiberglass Reinforced Plastic (FRP) Coating:
   1. Carbon steel pipe, ASTM A53/A53M, Grade B, Schedule 40 for diameters through 125 mm (5 inches), 3.4 mm (0.134 inch) thick for diameters greater than 125 mm (5 inches) up thru 660 mm (26 inches). All welded construction.
   2. Blast clean exterior per NACE 4/SSPC-SP7.
   3. Apply fiberglass reinforced polyester (FRP) external cladding at least 2.5 mm (0.10 inches) thick with ultra-violet inhibitor. Cladding on field joints shall be equivalent to factory-applied cladding applied on remainder of system.
   4. Test entire system for holidays using a 35,000-volt holiday detector.
D. Glass Fiber Reinforced Plastic (FRP) Conduit:
   1. Conform to UL 971 and ASTM D2996 using a filament-winding process and epoxy or vinyl ester resins.
   2. Design pipe, fittings and joining system for carrier pipe fuel service, 65 degrees C (150 degrees F), 1034 kPa (150 psig) pressure, 68 kPa (20 inches Hg) vacuum.
   3. Provide an integral resin-rich liner, minimum thickness 0.25 mm (0.010 inch). Outer layer shall include ultra-violet inhibitors.
   4. Minimum total wall thickness 1.8 mm (0.07 inch) for diameters below 200 mm (8 inches), 2.8 mm (0.11 inch) for diameters 200 mm (8 inches) and 250 mm (10 inches), 5 mm (3/16 inch) for diameters 250

mm (10 inches) through 508 mm (20 inches), and 6 mm (1/4 inch) for diameters above 508 mm (20 inches).

E. Pipe Supports: Provide supports within conduit for fuel carrier pipes spaced 2100 mm (7 feet) apart except 3000 mm (10 feet) apart for carrier pipe size 50 mm (2 inches) through 100 mm (4 inches). Support design shall permit differential movement of pipes, allow drainage of leakage to sumps, and maintain alignment of carrier pipes.

F. Conduit End Seals: Same material and coating as conduit; leak tight.

G. Leak Detector Sensor Locations: On each piping system, provide sumps at the low points with water-tight openings above grade for access to leak detector sensors. Design sumps to intercept all potential leakage. Maximum spacing between sumps, 3000 mm (10 feet).

2.5 LEAK DETECTION SYSTEMS

A. Automatic digital continuous monitoring systems responsive to the presence of water and hydrocarbons in the interstitial space of the double-wall tanks, in the tank manhole access enclosures, and in the secondary containment of fuel piping systems. System shall distinguish between hydrocarbon and water and identify location of leak as to individual tank and piping system. System may be combined with tank fluid level monitor and alarm system specified in paragraph, TANK FLUID LEVEL MONITOR AND ALARM SYSTEM.

B. Functions and Arrangement:

1. Single control station to monitor all sensing probes.
2. Visual indicator to monitor and identify leaks as water or hydrocarbon and location.
3. Indicators showing system status including faults and alarms.
4. On board printer that provides complete reports of all system functions upon command.
5. Panel circuit test button.
6. 95 dB audible alarm with silencing control to sound when leak is detected.
7. Eight-hour memory backup system with battery.
8. NEMA 250 Type 4 cabinet.
9. UL or other accredited testing laboratory listing.

10. RS232 Modbus communications with engineering control system or boiler plant computer workstation to indicate system in service and alarm conditions.

C. Sensors:
   1. Designed for required locations including: Insertion between walls of double-wall tanks, in sumps in double-wall piping systems and in tank manhole enclosures. Sensing points shall be at lowest point of each tank or sump. Intrinsically safe design.
   2. Sensing units shall detect presence of water and a minimum 3.2 mm (1/8 inch) thick layer of hydrocarbon on surface of water and minimum 50 mm (2 inch) thickness of hydrocarbon in area that has no water present.
   3. Sensors shall be arranged to allow replacement of individual sensors without disturbing other portions of leak detection system or fuel storage and piping system. Underground sensors shall be accessed through caps as grade.
   4. Materials of construction shall be non-corroding.
   5. Transmit status signal to control unit.

D. Components:
   1. Provide manholes at grade for each sensor cap similar in construction to fill boxes. Manholes shall be cast iron, quick-opening cover, watertight, minimum size necessary to accommodate sensor caps. Provide identification plates, similar to those specified for fill points, labeled “MONITORING/OBSERVATION WELL-DO NOT FILL”. Provide special tools if necessary for opening covers.
   2. Sensor housings from tank and piping to grade shall be Schedule 40 PVC, or stainless steel.
   3. Underground wiring between probes and control unit: Place in water-tight corrosion-resistant conduit system conforming to Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION.

2.6 TANK FLUID LEVEL MONITOR AND ALARM SYSTEMS

A. Digital systems for central monitoring of fuel and water levels in all fuel oil storage tanks in the project. High and low level visual and audible alarms. Volumetric tank-tightness testing. Complete with all transducing, transmitting, and receiving devices. On board printer to provide complete report of all system functions upon command. System may be combined with leak detection system specified in paragraph, LEAK DETECTION SYSTEMS.

B. Fluid Level Monitor:
   1. Digital continuous readout, showing tank oil and water levels in gallons, smallest reading one gallon. Provide identification of product measured, measuring units, and the tank number.
   2. Tank and fuel characteristics contained in preprogrammed non-volatile field-replaceable databases. Protected power supply.
C. High and Low Fluid Level Alarm System:
   1. Automatic continuous on-line monitoring of all tanks.
   2. Visual and audible indicators combined with fluid level monitor. Identify the tank that is in alarm condition.
   3. Manual alarm test and silencing controls.
   4. Low level alarm actuation adjustable 0-25 percent of tank capacity. High level alarm actuation adjustable 75-100 percent of tank capacity.
D. Locate all indicators, selector switches, alarms on face of wall-mounted NEMA 250, Type 4 panel.
E. Remote Alarm Annunciator:
   1. Visual and audible high-level alarms adjacent to tank fill box locations. Locate in NEMA 250 Type 4X weatherproof exterior wall or pole-mounted panels.
   2. Alarm shall include flashing red light with 180-degree visibility for each tank and 95 dB horn or 100 mm (4 inch) diameter bell. Provide alarm silence control.
   3. Provide identification sign: "WHEN ALARM SOUNDS - FUEL TANK FILLED TO CAPACITY - DO NOT OVERFILL".
F. Modbus communication to engineering control system boiler plant computer workstation to indicate tank fluid level and alarm conditions. Telephone modem communication capability.
G. System Performance: Accuracy plus or minus 2.5 mm (0.10 inch) of fluid height in inventory mode and 0.25 mm (0.01 inch) in leak detection mode. Automatic compensation for fluid temperature changes. Volumetric tank tightness sensitivity of 0.4 lph (0.1 gph).

H. Sensors:

1. Provide sensor types such as magnetostrictive, capacitance, float, hydrostatic and other types as necessary for the applications.
2. Apply in accordance with manufacturer’s instructions with provisions for easy future replacement without need for excavation.
3. Provide for each hydrostatic sensor a constant flow differential pressure regulator and transmitter protected from fuel contamination. Air supply shall include filter and over-pressure protection. Provide desiccant-type dryer on air supply designed for removal of water vapor. Dryer rating, minimum 4.6 L/s (10 SCFM). Provide moisture indicator. Dryer may be deleted if air supply source has a refrigerated dryer.
4. Float-type units shall be designed for installation and removal through a 100 mm (4 inch) diameter vertical pipe mounted in the top of the tank.

I. Underground Wiring and Piping: Enclose in water-tight corrosion-resistant conduit system sized and arranged as recommended by system manufacturer and conforming to Section 26 05 41, UNDERGROUND ELECTRICAL CONSTRUCTION.

J. Code Conformance: NFPA 70.

2.7 FUEL OIL QUALITY MAINTENANCE SYSTEMS

A. Complete factory-assembled automatic particulate filtration and dewatering and fuel additive injection system to maintain the purity of No. 2 fuel oil in storage. The system shall circulate the oil from the storage tank, through the system, and back to the storage tank. Provide quantity and capacity of systems to serve tanks as shown, connected to the tank pump-out and return pipes. Drawings may show multiple tanks served by one system. Smaller systems without large water storage tanks and without fuel additive injection shall be wall-mounted. Units with water storage tanks and/or additive injection shall be floor-mounted on steel skids on concrete foundations. Digital controls.

B. Performance: Design for nearly 100 percent water removal. Provide 2-micron particulate filtration. Each system shall have capacity to turn over the largest connected full tank one time within 17 hours maximum. System shall be designed to allow continuous operation with brief interruptions to manually change filters and clean strainers.

C. Components:
  1. Strainer: 100 mesh perforated stainless steel basket. Clamped covers. 861 kPa (125 psig) design pressure.
  2. Water Separation Unit: Two stage, designed to reduce water content of fuel to less than 10 ppm. Centrifugal separator for removal of large droplets and renewable resin-impregnated cellulose water coalescing elements. Water removed shall flow to water holding sump in the unit. Water sensing probe to alert the operator when water level in bowl has reached capacity. Automatic pumped drain to holding tank actuated by electronic water level sensing devices in the separation unit.
  3. Filter: 2-micron filtration with 96 percent removal efficiency, valved manual drain. Replaceable elements.
  4. Filtration Pump: Positive displacement base-mounted pump with cast iron or bronze housing, for circulating the oil from the storage tank, through the water separation and filter units and back to the storage tank. Pump shall have carbon bushings, stainless steel shaft and Teflon mechanical seal, ODP motor.
  5. Controls:
     a. Digital PLC electronic controls for all system control and alarm functions. Relay logic not acceptable.
     b. Control panel with selector for modes of operation, indicators to show system status, and visual and audible alarms to signal the need for operator intervention. Operator interface shall be 2 x 20 LCD and keypad.
     c. Controls shall include:
        1) Control power “on-off”.
        2) “Cycle Start”.
        3) “Cycle Cancel”.
        4) “Hand-off-Auto” for filtration pump.
        5) Pump cycle timer set function.
        6) Cycle duration selector.
        7) “Auto-Off” switch for water transfer pump.
        8) “Auto-Off” for chemical additive pump.
     d. Indications shall include:
        1) “Control Power On”.

2) “Pump Run”.
3) “Pump Failure”.
4) “Excess Water in Fuel”.
5) “Filter Water Level High”.
6) “Rupture Basin Leak” alarm.
7) “High Pressure Drop in Strainer” alarm.
8) “High Pressure Drop in Filters” alarm.
9) “High Pressure” alarm and automatic shutdown.
10) “High Water Level” in water storage tank.

e. Filter and strainer differential pressure gauges, differential pressure switches and control. Provide indication when filters should be changed.
f. Over pressure switch and control to shut down pump if filter inlet pressure exceeds limits.
g. All primary wiring exiting the enclosure shall be encased in conduit.
h. Magnetic motor starters with overload protection.
i. Circuit breakers.
j. Control enclosure shall be NEMA 4, fully gasketed doors with 3 point lockable latching. Interior shall have white gloss finish; exterior shall be chemical-resistant gray enamel. All controls and indicating devices shall be mounted on front of enclosure and labeled with black Phenolic labels with white lettering.
k. Modbus communication to engineering control systemand boiler plant computer workstation for alarms and system status.

D. Enclosure – Wall Mounted Units: 14-gauge steel, NEMA Type 4 enclosure, continuously welded, framed cabinet. Provide doors for complete access to all equipment. Doors shall have a turned edge, piano hinges, three-point locking mechanisms. Corrosion-resistant prime and finish coatings on all interior and exterior surfaces.

E. Waste Water Holding and Removal System: Automatic system with gear pump and 5gallon holding tank. System shall sense water in the filter enclosure, automatically start the pump to remove water from the water separation/filter system and pump it into the holding tank. If water collected in the filter enclosure exceeds the pumping capacity, the filtration system shall automatically stop. Provide hand pump with outlet hose connection for emptying water from holding tank. Provide automatic valves that prevent oil flow into the tank or water flow out of the tank back into the oil system when the system is idle. Tank construction shall be centrifugally cast fiberglass reinforce isophthalic polyester resin. Tank shall have high level alarm and interlock to shut down the filtering system when the tank is full.

F. Chemical Additive System: Provide welded steel chemical storage tank and chemical pump that shall automatically add chemical to the fuel being circulated. Tank shall be sized to hold five years supply of additive as recommended by additive supplier. Pump shall be positive displacement metering type with totally enclosed 250-watt (1/3 hp) motor, cast iron pump body, stainless steel trim and Teflon diaphragm. Output of pump shall be adjustable for 0 to 100 percent of capacity. Control system shall automatically operate the pump for an adjustable time period during each filtration cycle.

G. Piping: Refer to Section 23 21 11, BOILER PLANT PIPING SYSTEMS.

H. Pressure Gauges: Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.

2.8 CONCRETE FOUNDATIONS

A. Concrete ballast foundations for underground tanks and concrete pads for aboveground tanks are specified under Section 03 30 00, CAST-IN-PLACE CONCRETE. Ballast foundations shall be sized for buoyancy of entire tank when empty. Credit for overburden is allowed.

2.9 BURIED UTILITY WARNING TRACING TAPE

A. Tape shall be 0.1 mm (0.004 inch) thick, 150 mm (6 inches) wide, yellow polyethylene with a metallic core, acid and alkali-resistant and shall have a minimum strength of 12,000 kPa (1740 psig) lengthwise and 10,342 kPa (1500 psig) crosswise with an elongation factor of 350 percent. Provide bold black letters on the tape identifying the type of system. Insulating and labeling shall be unaffected by moisture and other substances contained in the backfill material.

PART 3 - EXECUTION

3.1 GENERAL

A. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no additional cost or time to the Government.

3.2 INSTALLATION AND TESTING, ABOVEGROUND TANKS

A. Conform to NFPA 30 or NFPA 31 as applicable.

B. Support tanks on steel saddles welded to the tanks. Anchor to concrete foundations. Provide molded neoprene isolation pads between the steel supports and the concrete foundation.

C. After tanks are installed, test steel tanks with air pressure of 21 kPa to 34 kPa (3 to 5 psig), using soapsuds to locate leaks. Repair leaks by chipping to bare metal and rewelding. Retest until all leaks are repaired. Repair all damaged areas of prime coat on tanks and steel dikes (if furnished). Test interstitial area between steel tank walls with air at pressure recommended by tank manufacturer. Tests shall be witnessed by the COR.

D. For steel tanks storing heated oil, field-applied insulation requirements are specified under Section 23 07 11, HVAC AND BOILER PLANT INSULATION.

E. Surface finish coating for tanks and steel dikes (if furnished) is specified under Section 09 91 00, PAINTING.

F. Provide electrical grounding in accordance with NFPA 70.

3.3 INSTALLATION AND TESTING, UNDERGROUND PIPING SYSTEMS

A. Leak Detection System: Arrange fuel and tracing media (if required for heated oil) carrier piping, enclosed in secondary containment piping, to accommodate leak detection system. Slope piping down toward tanks and leak detectors at 25 mm in 12 m (1 inch in 40 feet).

B. Steel Fuel and Tracing Media Carrier Piping: All joints butt or socket welding. Threaded piping is prohibited. Piping ends shall be accurately cut, true, and beveled for welding.

C. Glass Fiber Reinforced Plastic (FRP) Fuel Carrier Piping and Secondary Containment Piping: Install in accordance with printed instructions of pipe manufacturer. Installation personnel trained in accordance with paragraph, QUALITY ASSURANCE. Plastic piping is prohibited in the same secondary containment system with steam or condensate piping.

D. Secondary Containment Piping:

1. Provide sand bedding and backfill material for steel piping and pea gravel for FRP piping.
2. Top of system 450 mm (18 inches) minimum below grade.

3. Design and locate leak detector sumps to intercept all potential leakage. Maximum spacing along each system, 3000 mm (10 feet).
4. Seal all building and manhole wall penetrations with a modular, watertight flexible penetration seal system. The modular penetration seal shall have a nitrile rubber seal, or if a fire separation is required, a high temperature silicone fire seal.
5. After placing system, prior to backfill, repair all damage, including coatings, as recommended in printed instructions of system manufacturer. Perform 10,000-volt holiday test on coated steel systems.
6. Fuel oil piping is prohibited in the same secondary containment system as steam or condensate piping.
7. On steel systems that do not have FRP cladding, install cathodic protection system.

E. Anchorage of System: When heated oil system is provided, anchor systems and provide expansion loops and bends as shown and as recommended by manufacturer of system. Pipe stress due to thermal expansion shall not exceed the limits in ASME B31.1.

F. Leak Test: Test carrier pipes with air pressure at 690 kPa (100 psig), and test the containment piping with air pressure at 55 kPa (8 psig). Systems shall hold the pressure for 30 minutes. Repair all leaks and retest.

G. Coatings for Steel Piping not in Secondary Containment System: Provide urethane coating and cathodic protection.

3.4 INSTALLATION AND TESTING, LEAK DETECTOR SYSTEMS FOR TANKS AND PIPING

A. Wiring shall conform to NFPA 70.

B. Locate control monitor panels 1500 mm (5 feet) above the floor on inside wall of boiler room, generator room or garage, depending on type of fuel tank served, unless shown otherwise.

C. Test operation of each probe, and monitoring system with fuel and water. If type of probe utilized is damaged by exposure to fuel, provide temporary probe for testing monitoring system.

3.5 INSTALLATION, TANK FLUID LEVEL INDICATOR AND ALARM SYSTEM

A. Wiring shall conform to NFPA 70.

B. Locate level indicator and alarm panel 1500 mm (5 feet) above the floor on inside wall of boiler room, generator room or garage, depending on type of fuel tank served, unless shown otherwise.

C. Locate remote high-level alarm on exterior wall or pole in view of tank fill point, 2400 mm (8 feet) above grade.

3.6 INSTALLATION, BURIED UTILITY WARNING TRACING TAPE

A. Install tracer wire in the trench approximately 457 mm (18 inches) above the non-metallic pipe. The tracer wire shall be taped approximately every 3 m (10 feet) to the pipe, where practical. The tracer wire shall be installed so that electrical continuity is maintained throughout the pipe system. As few connections as possible shall be made in the tracer wire. The wire shall be contiguous except at test stations, valve boxes, and where splicing is required. All splices shall be encased. Connections will be made by stripping the insulation back one inch and joining the two ends using an approved mechanical connector and a split bolt connector. Twisting of copper wire is prohibited. To complete this connection, wrap all exposed wire thoroughly with electrical tape. A minimum 1.5 m (5 foot) of additional tracer wire will be coiled, buried and terminate aboveground at the ends of the pipeline.

3.7 INSTALLATION, FUEL OIL QUALITY MAINTENANCE SYSTEMS

A. Locate systems within easy reach of persons standing on floor, with sufficient elevation to allow gravity flow of water from system to water storage tank sitting on the floor.

B. Connect to tank suction and return piping systems with isolation valves. Provide compound pressure gauges at suction and discharge piping connections. Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT for gauge requirements.

3.8 STARTUP AND TESTING

A. Perform tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.

B. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.

C. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with COR and Commissioning Agent. Provide a minimum notice of 10 working days prior to startup and testing.

3.9 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

B. Components provided under this section of the specification will be tested as part of a larger system.

3.10 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer’s technical representative for 4 hours to instruct each VA personnel responsible in operation and maintenance of the system.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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SECTION 23 11 23
FACILITY NATURAL-GAS PIPING

1.1 DESCRIPTION

A. Fuel gas systems, including piping, equipment and all necessary accessories as designated in this section. Fuel gas piping for central boiler plants is not included.

B. A complete listing of common acronyms and abbreviations are included in Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION Section 23 05 11, COMMON WORK RESULTS FOR HVAC Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

D. Section 07 84 00, FIRESTOPPING.

E. Section 07 92 00, JOINT SEALANTS.

F. Section 09 91 00, PAINTING.

G. Section 22 05 11, COMMON WORK RESULTS FOR PLUMBING.

H. Section 22 05 23, GENERAL DUTY VALVES FOR PLUMBING PIPING.

I. Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

J. Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.

K. Section 23 21 11, BOILER PLANT PIPING 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. Where conflicts occur these specifications and the VHA standard will govern.

B. American Society of Mechanical Engineers (ASME):

B16.3-2019.............Malleable Iron Threaded Fittings: Classes 150 and 300

B16.9-2018.............Factory Made Wrought Buttwelding Fittings

B16.11-2011............Forged Fittings, Socket-Welding and Threaded

B16.15-2018............Cast Copper Alloy Threaded Fittings: Classes 125 and 250

B16.40-2019............Manually Operated Thermoplastic Gas Shutoffs and Valves in Distribution Systems

B31.8-2018..............Gas Transmission and Distribution Piping Systems

C. American Society for Testing and Materials (ASTM):

A47/A47M-2018...........Standard Specification for Ferritic Malleable Iron Castings

A53/A53M-2018...........Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

A536-2019...............Standard Specification for Ductile Iron Castings

A733-2016...............Standard Specification for Welded and Seamless Carbon Steel and Austenitic Stainless-Steel Pipe Nipples

B43-2015................Standard Specification for Seamless Red Brass Pipe, Standard Sizes

B687-2016...............Standard Specification for Brass, Copper, and Chromium-Plated Pipe Nipples

D2513-2019..............Standard Specification for Polyethylene (PE) Gas Pressure Pipe, Tubing, and Fittings

D2683-2014..............Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing

D3261-/2016.............Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing

D. American Water Works Association (AWWA):

C203-2015...............Coal-Tar Protective Coatings and Linings for Steel Water Pipes

E. International Code Council (ICC):

IFGC-2018...............International Fuel Gas Code

IPC-2018................International Plumbing Code

F. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS):

SP-72-2010a.............Ball Valves with Flanged or Butt-Welding for General Service

SP-110-2010.............Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends

G. NACE International (NACE):

SP0274-2011.............High-Voltage Electrical Inspection of Pipeline Coatings

SP0490-2007.............Holiday Detection of Fusion-Bonded Epoxy External Pipeline Coating of 250 to 760 µm (10 to 30 mil)

H. National Fire Protection Association (NFPA):

54-2018 ....National Fuel Gas Code

1.4 SUBMITTALS

A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 23 11 23, FACILITY NATURAL-GAS PIPING", with applicable paragraph identification.

C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.

1. Pipe & Fittings.
2. Valves.
3. Strainers.
4. All items listed in Part 2 - Products.

D. Detailed shop drawing of clamping device and extensions when required in connection with the waterproofing membrane.

E. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replacement parts, and troubleshooting guide:

1. Include complete list indicating all components of the systems.
2. Include complete diagrams of the internal wiring for each item of equipment.
3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

F. Completed System Readiness Checklist provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

G. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

1.5 AS-BUILT DOCUMENTATION

A. Submit manufacturer’s literature and data updated to include submittal review comments and any equipment substitutions.

B. Submit operation and maintenance data updated to include submittal review comments, VA approved substitutions and construction revisions shall be in electronic version on CD or DVD inserted into a three-ring binder. All aspects of system operation and maintenance procedures, including applicable piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices shall be included. A List of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.

C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the ‘third party testing company’ requirement. Provide record drawings as follows:

   1. As-built drawings are to be provided, with a copy of them on AutoCAD provided on CD or DVD. The CAD drawings shall use multiple line layers with a separate individual layer for each system.

D. The as-built drawings shall indicate the location and type of all lockout/tagout points for all energy sources for all equipment and

pumps to include breaker location and numbers, valve tag numbers, etc. Coordinate lockout/tagout procedures and practices with local VA requirements.

E. Certification documentation shall be provided to COR 21 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and provide documentation/certification that all results of tests were within limits specified. Test results shall contain written sequence of test procedure with written test results annotated at each step along with the expected outcome or setpoint. The results shall include all readings, including but not limited to data on device (make, model and performance characteristics), normal pressures, switch ranges, trip points, amp readings, and calibration data to include equipment serial numbers or individual identifications, etc.

1.6 SYSTEM PRESSURE

A. Natural gas systems unless otherwise noted are designed and materials and equipment selected to prevent failure under gas pressure of (100 psig).

PART 2 - PRODUCTS

2.1 FUEL GAS SERVICE CONNECTIONS TO BUILDING

A. From inside face of exterior wall to a distance of approximately 1500 mm (5 feet) outside of building.

B. Pipe: Black steel, ASTM A53/A53M, Schedule 40. Shop-applied pipe coating shall be one of the following types:

1. Coal Tar Enamel Coating: Exterior of pipe and fittings shall be cleaned, primed with Type B primer and coated with hot-applied coal tar enamel with bonded layer of felt wrap in accordance with AWWA C203. Asbestos felt shall not be used; felt material shall be fibrous glass mat in accordance with AWWA C203.

C. Holiday Inspections: Procedure for holiday inspection: Holiday Inspection shall be conducted on all coatings to determine the presence and number of discontinuities in those coatings using a Tinker & Rasor model AP/W Holiday Detector or equal. Holiday inspection shall be performed in a manner spelled out in the Tinker & Rasor operating instructions and at a voltage level recommended by the coating manufacturer or applicable NACE standard such as SP0274 or SP0490 in the case thermosetting epoxy coating. Holiday Detectors shall be calibrated and supplied with a certificate of calibration from the factory. A calibration of the Holiday Detector shall be performed once every 6 months to verify output voltages are true and correct.

D. Steel Fittings:
   1. Butt weld fittings, wrought steel, ASME B16.9.
   2. Socket weld and threaded fittings forged steel, ASME B16.11.
   3. Grooved End: Ductile iron (ASTM A536, Grade 65-45-12), malleable iron (ASTM A47/A47M, Grade 32510), or steel (ASTM A53/A53M, Type F or Type E or S, Grade B).

E. Steel Joints: Welded, ASME B31.8.

2.2 EMERGENCY GAS SAFETY SHUT-OFF VALVE WITH EARTHQUAKE SENSOR

A. Permits remote shut-off of fuel gas flow to boiler plant.

B. Type: Manually opened, electrically held open, automatic closing upon power interruption. Pneumatic operator is prohibited.

C. Performance: Shall shut bubble tight within one second after power interruption. Refer to the drawings for pressure, flow, and valve size requirements.

D. Service: Natural gas and LP gas.

E. Construction: UL listed, FM approved, rated for 861 kPa (125 psig) ASME flanged ends for pipe sizes above 50 mm (2 inches), threaded ends for pipe sizes 50 mm (2 inches) and under. Cast iron, cast steel or bronze body, open and shut indicator. Valves for LP gas service shall be rated at 1725 kPa (250 psig).

F. Control Switch: Mounted at exterior doorways (multiple switches). Switch shall also cut the power to the fuel oil pump set. Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT. Provide auxiliary switch to operate annunciator on Boiler Plant Instrumentation Panel and provide signal to Computer Work Station.

G. Earthquake Sensor: Mechanical device which automatically breaks 120-volt electrical circuit to safety shut off valve when earthquake occurs allowing valve to automatically close. UL listed and shall comply with State of California Standard Codes (Part 12 Title 24 CAC). Valve shall close within 5 seconds after sensor is subjected to horizontal sinusoidal oscillation having a peak acceleration of 2.94 m/sec^2 (0.3g) and a period of 0.4 seconds. The valve shall not shut off when the sensor is subjected for 5 seconds to horizontal, sinusoidal oscillations having: a peak acceleration of 3.92 m/sec^2 (0.4g) with a period of 0.1 second; a peak acceleration of 0.78 m/sec^2 (0.08g) with a period of 0.4 second; peak acceleration of 0.78 m/sec^2 (0.08g) with a period of 1.0 second. Sensor shall be corrosion-resistant for outside location. Manufacturer: Quake-Defense or equal.

2.3 FUEL GAS PIPING ABOVE GROUND

A. Pipe: Black steel, ASTM A53/A53M, Schedule 40.

B. Nipples: Steel, ASTM A733, Schedule 40.

C. Fittings:

1. Sizes 50 mm (2 inch) under ASME B16.3 threaded malleable iron.
2. Over 50 mm (2 inch) and up to 100 mm (4 inch) ASME B16.11 socket welded.
3. Over 100 mm (4 inch) ASME B16.9 butt welded.

D. Joints: Provide welded or threaded joints.

E. Threaded Metallic Joints: Threaded joints in metallic pipe shall have tapered threads evenly cut. Metal screwed pipe joints shall be made leak-tight by applying Rector Seal No. 5 pipe thread sealant to all threaded joints. Care must be taken to prevent the pipe dope compound from getting inside the internal pipeline. Teflon tape type sealant is prohibited.

2.4 EXPOSED FUEL GAS PIPING

A. Finished Room: Use full iron pipe size chrome plated brass piping for exposed fuel gas piping connecting fixtures, casework, cabinets, equipment and reagent racks when not concealed by apron including those furnished by the Government or specified in other sections.

1. Pipe: ASTM B43, standard weight.
2. Fittings: ASME B16.15 cast bronze threaded fittings with chrome finish, (125 and 250).
3. Nipples: ASTM B687, Chromium-plated.
4. Unions: 50 mm (2 inches) and smaller MSS SP-72, MSS SP-110, brass or bronze threaded with chrome finish. Unions 65 mm (2-1/2 inches) and larger shall be flange type with approved gaskets.
5. Valves: MSS SP-72, MSS SP-110, brass or bronze with chrome finish.

B. Unfinished Rooms, Mechanical Rooms and Kitchens: Chrome-plated brass piping is not required. Paint piping systems as specified in Section 09 91 00, PAINTING.

2.5 VALVES

A. Ball Valve: Bronze body, rated for 1034 kPa at 185 degrees C (150 psig at 365 degrees F), 1723 kPa at 121 degrees C (250 psig at 250 degrees F), reinforced TFE seat, stem seal and thrust washer; end entry, threaded ends, UL-listed for natural or LP gas shut off service when used on those services.

B. Gas Vent Cocks: Type 701: Bronze body, tee handle, rated for 207 kPa at 38 degrees C (30 psig at 100 degrees F), ground plug, rated for tight shut-off on fuel gas service.

2.6 WATERPROOFING

A. Provide at points where pipes pass through membrane waterproofed floors or walls in contact with earth.

B. Floors: Provide cast iron stack sleeve with flashing device and a underdeck clamp. After stack is passed through sleeve, provide a waterproofed caulked joint at top hub.

C. Walls: See detail shown on drawings.

2.7 STRAINERS

A. Provide on high pressure side of pressure reducing valves, 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. Gas Lines: "Y" type with removable mesh lined brass strainer sleeve.

C. Body: Smaller than 75 mm (3 inches), brass or bronze; 75 mm (3 inches) and larger, cast iron or semi-steel.

2.8 DIELECTRIC FITTINGS

A. Provide dielectric couplings or unions between ferrous and non-ferrous pipe.

2.9 GAS EQUIPMENT CONNECTORS

A. Flexible connectors with Teflon core, interlocked galvanized steel protective casing, AGA certified design.

2.10 FUEL GAS PIPING BELOW GROUND

A. Thermoplastic (Polyethylene - PE): PE pipe and heat fusion fittings shall conform to ASTM D2513, SDR 11 and manufactured for 861 kPa (125 psig) working pressure. Pipe and fittings shall have heat fusion joints PE pipe and fitting materials for heat fusion shall be compatible to ensure uniform melting and a proper bond.

B. Fittings:
   1. Socket Fusion Fittings: ASTM D2683.
   2. Butt Fusion Fittings: ASTM D3261, molded and matching pipe dimensions.

C. Risers: Manufacturer's standard anodeless type riser, transition from plastic to steel pipe with fusion bonded epoxy coating. Inlet connection socket or butt weld or swaged gas-tight construction with O-ring seals, metal insert, and protective sleeve. Outlet or above ground connection end shall be threaded or flanged. Riser shall comply with ASTM A53/A53M, Type F and E, Grade A, Schedule 40.

D. Polyethylene ball valves, ASME B16.40 shall be manufactured and rated for underground gas service. Operating pressure to 861 kPa (125 psig) (SDR 9.3). Valve shall be maintenance and corrosion free. Polyethylene valves shall be full port opening type. Valves shall be wrench operated. Wrench operated valves shall have a 50 mm (2 inch) square adaptor securely fastened to the valve stem. Polyethylene valves shall be installed by butt fusion method.

2.11 VALVE BOXES

A. Provide each valve on buried piping with a plastic or cast iron valve box of a size suitable for the valve. Valve box shall have a round cover with the word "Gas" cast on it. A metal tag or label shall be installed on top or inside of each valve box lid. The tag shall designate the appropriate location number, valve size, and other pertinent information. Each cast iron box shall be given a heavy coat of bituminous paint. Provide adjustable box extensions of length required for depth of buried valve.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General: Comply with the ICC IFGC, ICC IPC and the following:
   1. Install branch piping for fuel gas and connect to all fixtures, valves, cocks, outlets, casework, cabinets and equipment, including those furnished by the Government or specified in other sections.

2. Pipe shall be round and straight. Cutting shall be done with proper tools. Pipe, shall be reamed to full size after cutting.
3. All pipe runs shall be laid out to avoid interference with other work.
4. Install valves with stem in horizontal position whenever possible. All valves shall be easily accessible.
5. Install union and shut-off valve on pressure piping at connections to equipment.
6. Pipe Hangers, Supports and Accessories:
   a. All piping shall be supported per the ICC IFGC.
   b. Shop Painting and Plating: Hangers, supports, rods, inserts and accessories used for Pipe supports shall be shop coated with red lead or zinc Chromate primer paint. Electroplated copper hanger rods, hangers and accessories may be used with copper tubing.
   c. Floor, Wall and Ceiling Plates, Supports, Hangers:
      1) Solid or split unplated cast iron, chrome plated in finished areas.
      2) All plates shall be provided with set screws.
      3) Pipe Hangers: Height adjustable clevis type.
      4) Adjustable Floor Rests and Base Flanges: Steel.
      5) Concrete Inserts: "Universal" or continuous slotted type.
      6) Hanger Rods: Mild, low carbon steel, fully threaded or Threaded at each end with two removable nuts at each end for positioning rod and hanger and locking each in place.
      7) Riser Clamps: Malleable iron or steel.
      8) Rollers: Cast iron.
      9) Self-drilling type expansion shields shall be "Phillips" type, with case hardened steel expander plugs.
      10) Miscellaneous Materials: As specified, required, directed or as noted on the drawings for proper installation of hangers, supports and accessories.
7. Install cast chrome plated escutcheon with set screw at each wall, floor and ceiling penetration in exposed finished locations and within cabinets and millwork.

8. Penetrations:
   a. Fire Stopping: Where pipes pass through fire partitions, fire walls, smoke partitions, or floors, install a fire stop that provides an effective barrier against the spread of fire, smoke and gases as specified in Section 07 84 00, FIRESTOPPING. Completely fill and seal clearances between piping and openings with the fire stopping materials.
   b. Waterproofing: At floor penetrations, completely seal clearances around the pipe and make watertight with sealant as specified in Section 07 92 00, JOINT SEALANTS.

B. Fuel gas piping shall conform to the following:
   1. Entire fuel gas piping installation shall be in accordance with requirements of NFPA 54.
   2. Provide fuel gas piping with plugged drip pockets at low points.
   3. Seismic Data: Refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS. Install automatic shutoff valve (earthquake valve) on discharge side of meter. Valve shall positively shut off supply of gas in case of pressure failure, remain shut off until manually reopened, and be provided with outside adjustment for reset.

C. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no additional cost or time to the Government.

3.2 CLEANING OF SYSTEM AFTER INSTALLATION

A. Clean all piping systems to remove all dirt, coatings and debris. Remove all valves, controls etc., and reinstall after piping system has been cleaned.

3.3 TESTS

A. General: Test system either in its entirety or in sections after system is installed or cleaned.

B. Test shall be made in accordance with Section 406 of the International Fuel Gas Code. The system shall be tested at a minimum of 1.5 times maximum working pressure, but not less than 5 psig (21 kPa).

C. System Purging: After completing pressure tests, and before testing a gas-contaminated line, purge line with nitrogen at junction with main line to remove all air and gas. Clear completed line by attaching a test pilot fixture at capped stub-in line at building location and let gas flow until test pilot ignites. Procedures shall conform to NFPA 54 and ASME B31.8.

3.4 STARTUP AND TESTING

A. Perform tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.

B. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.

C. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with COR and Commissioning Agent. Provide a minimum notice of 10 working days prior to startup and testing.

3.5 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 4 hours to instruct each VA personnel responsible in operation and maintenance of the system.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 22 08 00, COMMISSIONING OF PLUMBING SYSTEMS.

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SECTION 23 21 11
BOILER PLANT PIPING SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

A. All boiler plant piping systems, except plumbing and sanitary, including piping supports. Piping located outside of the boiler plant building is not included except for gas regulator and meter stations.

B. A complete listing of common acronyms and abbreviations are included in Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

D. Section 09 91 00, PAINTING.

E. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

F. Section 22 11 00 FACILITY WATER DISTRIBUTION.

G. Section 22 31 11, WATER SOFTENERS.

H. Section 22 67 19.16, REVERSE OSMOSIS WATER EQUIPMENT.

I. Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION.

J. Section 23 05 51, NOISE AND VIBRATION CONTROL FOR BOILER PLANT.

K. Section 23 05 93, TESTING, ADJUSTING, AND BALANCING FOR HVAC.

L. Section 23 07 11, HVAC AND BOILER PLANT INSULATION.

M. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

N. Section 23 08 11, DEMONSTRATIONS AND TESTS FOR BOILER PLANT.

O. Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.

P. Section 23 50 11, BOILER PLANT MECHANICAL EQUIPMENT.

Q. Section 23 52 39, FIRE-TUBE BOILERS.

1.3 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Where conflicts occur these specifications and the VHA standard will govern.

B. American Society of Civil Engineers (ASCE):

25-2006................Earthquake-Actuated Automatic Gas Shutoff Devices

C. American Society of Mechanical Engineers (ASME):

B16.3-2011.............Malleable Iron Threaded Fittings: Classes 150 and 300

B16.5-2013.............Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24 Metric/Inch Standard

B16.9-2018.............Factory Made Wrought Buttwelding Fittings

B16.11-2016............Forged Fittings, Socket-Welding and Threaded

B16.22-2018............Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings

B16.34-2017............Valves Flanged, Threaded and Welding End

B31.1-2014(R2017).......Power Piping

B31.9-2014.............Building Services Piping

ASME Boiler and Pressure Vessel Code (BPVC):

BPVC Section I-2019.....Rules for Construction of Power Boilers

BPVC Section VIII-2019 Rules for Construction of Pressure Vessels

BPVC Section IX-2019 Welding, Brazing, and Fusing Qualifications

D. ASTM International (ASTM):

A47/A47M-2018..........Standard Specification for Ferritic Malleable Iron Castings

A53/A53M-2018..........Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

A105/A105M-2018.........Standard Specification for Carbon Steel Forgings for Piping Applications

A106/A106M-2019.........Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service

A193/A193M-2019.........Standard Specification for Alloy-Steel and Stainless-Steel Bolting for High Temperature or High-Pressure Service and Other Special Purpose Applications

A194/A194M-2018.........Standard Specification for Carbon Steel, Alloy Steel, and Stainless-Steel Nuts for Bolts for

High Pressure or High-Temperature Service, or Both

A197/A197M-2019.........Standard Specification for Cupola Malleable Iron

A216/A216M-2018.........Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, For High-Temperature Service

A234/A234M-2018a........Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service

A269/A269M-2019.........Standard Specification for Seamless and Welded Austenitic Stainless-Steel Tubing for General Service

A395/A395M-R2018........Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures

B62-2017................Standard Specification for Composition Bronze or Ounce Metal Castings

B88-2016................Standard Specification for Seamless Copper Water Tube

E. American Welding Society (AWS):

B2.1/B2.1M-2014.........Specification for Welding Procedure and Performance Qualification

Z49.1-2012..............Safety in Welding and Cutting and Allied Processes

F. Manufacturers Standardization Society of the Valve and Fittings Industry (MSS):

SP-45-2014..............Bypass and Drain Connections

SP-58-2018..............Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation

SP-80-2013..............Bronze Gate, Globe, Angle and Check Valves

SP-97-2019..............Integrally Reinforced Forged Branch Outlet Fittings – Socket Welding, Threaded, and Buttwelding Ends

SP-127-2014a............Bracing for Piping Systems: Seismic – Wind – Dynamic Design, Selection, and Application

G. National Fire Protection Association (NFPA):

30-2019.................Flammable and Combustible Liquids Code

31-2019.................Standard for the Installation of Oil-Burning Equipment

54-2019.................National Fuel Gas Code

85-2019.................Boiler and Combustion Systems Hazards Code

H. Pipe Fabrication Institute (PFI):

ES24-2016...............Pipe Bending Methods, Tolerances, Process and Material Requirements

I. Department of Veterans Affairs (DVA):

H-18-8-2016.............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 23 21 11, BOILER PLANT PIPING 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. Piping:
   a. ASTM material specification number.
   b. Grade, class or type, schedule number.
   c. Manufacturer.
   d. Intended service.
2. Pipe Fittings, Unions, Flanges:
   a. ASTM material specification number.
   b. ASME standards number.
   c. Catalog cuts.
   d. Pressure and temperature ratings.
   e. Intended service.

3. Valves - Gate, Globe, Check, Plug, Butterfly, Ball:
   a. Catalog cuts showing design and construction.
   b. Pressure and temperature ratings.
   c. Materials of construction.
   d. Accessories.
   e. Intended service.
4. Sight Flow Indicators:
   a. Catalog cuts showing design and construction.
   b. Pressure and temperature ratings.
   c. Materials of construction.
   d. Intended service.
5. Quick - Couple Hose Connectors and Steam Hose:
   a. Catalog cuts showing design and construction.
   b. Pressure and temperature ratings.
   c. Materials of construction.
   d. Type of seal between couplings.
   e. Flexibility of steam hose.
6. Pressure Reducing and Regulating Valves, Back Pressure Relief Valves, Safety Valves, Relief Valves:
   a. Catalog cuts showing design and construction.
   b. Service limitations (type of fluid, maximum pressure and temperatures).
   c. Materials of construction.
   d. Flow capacity at required set pressure or differential pressure.
   e. Predicted sound levels, at operating condition, for steam pressure reducing valves.
7. Strainers:
   a. Catalog cuts showing design and construction.
   b. Pressure and temperature ratings.
   c. Materials of construction.
   d. Strainer basket or liner mesh size.
   e. Pressure loss and flow rate data.
   f. Intended service.
8. Emergency Gas Safety Shutoff Valves and Automatic Earthquake Gas Valves:
   a. Catalog cuts showing design and construction.

b. Maximum pressure rating.

c. Material of construction.

d. Pressure loss and flow rate data.

9. Steam Traps:

a. Catalog cuts showing design and construction.

b. Service limitations (maximum pressures and temperatures).

c. Materials of construction.

d. Flow rates at differential pressures shown on drawings.

e. Orifice size for each trap.

f. Monitoring equipment or attachments

10. Flexible Connectors:

a. Catalog cuts showing design and construction.

b. Pressure and temperature ratings.

c. Materials of construction.

d. Maximum allowable lateral and axial movements.

e. Description of type of movement permitted, intermittent offset or continuous vibration.

f. Intended service.

11. Pipe Support Systems: The contractor shall provide the following with submissions.

a. Credentials of technical personnel who will design the support systems.

b. Description of computer program for pipe support selection indicating its capability and limitations. Provide documentation showing both program verification and validation results. List of projects where it was employed successfully.

c. Input and output data for pipe support selection program for all piping systems with pipe sizes 65 mm (2-1/2 inches) and above.

d. Boiler, feedwater deaerator and header manifold steam nozzle (pipe connection) allowable and actual forces and moments imposed by connecting piping.

e. Hanger load calculation methods and results for piping systems with pipe sizes 50 mm (2 inches) and below.

f. Piping layouts showing location and type of each hanger support and anchors with unique identifiers that can be referenced back to the calculation results.

g. Catalog cuts showing design and construction of each hanger support and anchor and their conformance to MSS standards.

h. Drawings showing arrangement and sizes of all components comprising each spring-type hanger and support assembly.

i. Load rating and movement tables for all spring hangers, and seismic shock absorbing devices.

j. Stress analyses on the boiler plant piping systems under all possible load conditions as part of the design. Once all piping is completed another stress analysis is required on the as built systems. Documentation results shall flag locations/components requiring recommended revision/modification to obtain acceptable stress levels.

D. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replacement parts, and troubleshooting guide:

1. Include complete list indicating all components of the systems.
2. Include complete diagrams of the internal wiring for each item of equipment.
3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

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 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

F. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

1.5 QUALITY ASSURANCE

A. Entire installation shall comply with ASME B31.1 and appendices and NFPA 54.

B. Boiler External Piping, as defined in the ASME BPVC Section I, is required to be constructed and inspected in conformance with the ASME Code.

C. The products and execution of work specified in this section shall conform to the referenced codes and standards as required by the specifications. Local codes and amendments shall be enforced, along with requirements of local utility companies. The most stringent requirements of these specifications, local codes, or utility company requirements shall always apply. Any conflicts shall be brought to the attention of the COR.

D. Welding Qualifications: Before any welding is performed, contractor shall submit a certificate certifying that welders comply with the following requirements:

1. Qualify welding processes and operators for piping according to ASME BPVC Section IX, AWS Z49.1 and AWS B2.1/B2.1M.
2. Comply with provisions in ASME B31.1.
3. Certify that each welder and welding operator has passed AWS qualification tests for welding processes involved and that certification is current and recent. Submit documentation to the COR.
4. All welds shall be stamped according to the provisions of the American Welding Society.

E. ASME Compliance: Comply with ASME B31.1 for materials, products, and installation. Safety valves and pressure vessels shall bear appropriate ASME labels.

1.6 DELIVERY, STORAGE AND HANDLING

A. All piping shall be stored and kept free of foreign material and shall be internally and externally cleaned of all oil, dirt, rust and foreign material. Deliver and store valves and pipe hangers in sealed shipping containers with labeling in place. Storage must be in dry, protected location.

1.7 INFORMATION ON PRESSURE-TEMPERATURE DESIGN OF PIPING SYSTEMS

A. Steam service pressures are selected to provide optimum pressure to the facilities served by the boiler plant. Main steam header pressure shall be controlled at 552 kPa (80 psig). Maximum pressure capability of steam systems between boilers and through first pressure reducing valve protected by a safety valve shall be governed by the pressure/temperature relationship of the highest safety valve setting shown for the boilers.

B. Steam distribution systems protected by safety valves following pressure reducing stations or protected by safety valves on the boilers shall be governed by the pressure/temperature relationship developed by the maximum setting of the safety valve on that system.

C. Boiler feedwater systems between boiler feed pumps, economizers (if provided), and boilers are designed for a normal maximum temperature of 138 degrees C (280 degrees F), and emergency temperature of 213 degrees C (415 degrees F) (if economizers are provided and economizer safety relief valve setting is 1896 kPa (275 psig)). Design pressure is the greater of: boiler feed pump shut off head; or 1896 kPa (275 psig) set pressure, plus accumulation, of economizer (if provided) relief valve.

D. Condensate collection and transfer systems to suction of boiler feed pumps are designed for maximum temperatures to 100 degrees C (212 degrees F), and pressures 276 kPa (40 psig). Vacuum return systems shall operate between 0 and 27 kPa (0 and 8-inch Hg) vacuum and equivalent steam saturation temperatures.

E. Natural gas fuel systems are designed, and materials and equipment are applied to prevent failure under gas pressure of (5 psig) entering Government property. LP gas systems for igniters (pilots) are designed for maximum LP tank pressure of 1724 kPa (250 psig).

F. Fuel oil system pressures are determined by the requirements of the burners and fuel trains. No. 2 oil systems are designed for maximum temperatures of 54 degrees C (130 degrees F), and pressures of 1034 kPa (150 psig).

G. Water service pressures are 482-551 kPa (70-80 psig) maximum. Systems are designed to operate under conditions of maximum available pressure.

H. Drips, drains, blowdown, water sampling, and chemical treatment are designed, and materials and equipment are applied in accordance with the maximum pressure and temperature of the system with which they are associated.

I. Low pressure steam, condensate, vacuum and vents are designed for service pressures and temperatures equivalent to 103 kPa (15 psig) saturated steam.

J. Compressed air systems are designed to accommodate a maximum pressure of 861 kPa (125 psig).

K. Instrumentation and control piping shall be provided for the service and pressure characteristics of the systems to which they are connected.

1.8 AS-BUILT DOCUMENTATION

A. Submit manufacturer's literature and data updated to include submittal review comments and any equipment substitutions.

B. Submit operation and maintenance data updated to include submittal review comments, VA approved substitutions and construction revisions shall be in electronic version on CD or DVD inserted into a three-ring binder. All aspects of system operation and maintenance procedures, including applicable piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices shall be included. A List of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.

C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the 'third party testing company' requirement. Provide record drawings as follows:

   1. As-built drawings are to be provided, with a copy of them on AutoCAD provided on CD or DVD. The CAD drawings shall use multiple line layers with a separate individual layer for each system

D. The as-built drawings shall indicate the location and type of all lockout/tagout points for all energy sources for all equipment and pumps to include breaker location and numbers, valve tag numbers, etc. Coordinate lockout/tagout procedures and practices with local VA requirements.

E. Certification documentation shall be provided to COR 21 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and provide documentation/certification that all results of tests were within limits specified. Test results shall contain written sequence of test procedure with written test results annotated at each step along with the expected outcome or setpoint. The results shall include all readings, including but not limited to data on device (make, model and performance characteristics), normal pressures, switch ranges, trip points, amp readings, and calibration data to include equipment serial numbers or individual identifications, etc.

PART 2 - PRODUCTS

2.1 STEAM PIPING

A. Pipe: Carbon steel, ASTM A53/A53M Grade B or ASTM A106/A106M Grade B, seamless or electric resistance welded (ERW). Schedule 40 for piping up to 861 kPa (125 psig) with welded ends. Schedule 80 for piping with threaded ends and piping over 861 kPa (125 psig) with welded ends.

B. Joints:

1. Pipe sizes 65 mm (2-1/2 inches) and above: Butt-welded, no other types allowed.
2. Pipe sizes 50 mm (2 inches) and below: Threaded, butt-welded, or socket-welded. Use Schedule 80 pipe and fittings for threaded joints.

C. Fittings:

1. Welded joints: Steel, ASTM A234/A234M, Grade B, ASME B16.9, same schedule as adjoining pipe, all elbows long radius.
2. Threaded joints: Forged steel, ASME B16.ll, 13,790 kPa (2000 psig) class. Use Schedule 80 pipe and fittings for threaded joints.
3. Socket-welded joints: Forged steel, ASME B16.11, 13,790 kPa (2000 psig) class.

D. Unions on Threaded Piping: Forged steel, 13,790 kPa (2000 psig) class or 20,685 kPa (3000 psig) class on piping 50 mm (2 inches) and under.

E. Flanges and Bolts: Forged steel weld neck, ASME B16.5, ASTM A105/A105M, 1034 kPa (150 psig) pressure class, except 2070 kPa (300 psig) class required adjacent to 1724 kPa (250 psig) and 2070 kPa (300 psig) class valves. Bolts shall be high strength steel ASTM A193/A193M, Class 2, Grade B7. Nuts shall be ASTM A194/A194M.

2.2 STEAM CONDENSATE PIPING

A. Includes all gravity, drip return, pumped and vacuum systems. Does not include piping system between boiler feed pumps and boilers.

B. Pipe: Carbon steel, ASTM A53/A53M Grade B or ASTM A106/A106M Grade B, seamless or ERW, Schedule 80.

C. Joints:

1. Pipe sizes 65 mm (2-1/2 inches) and above: Butt-welded, no other types allowed.
2. Pipe sizes 50 mm (2 inches) and below: Schedule 80 threaded, butt-welded or socket-welded.

D. Fittings:

1. Welded joints: Steel, ASTM A234/A234M, Grade B, ASME B16.9, same schedule as adjoining pipe.
2. Threaded joints: Forged steel, ASME B16.ll, 13,790 kPa (2000 psig class. Use Schedule 80 pipe and fittings for threaded joints.
3. Socket-welded joints: Forged steel, ASME B16.11, 13,790 kPa (2000 psig) class.

E. Unions on Threaded Piping: For piping 50 mm (2 inches) and under, forged steel, 13,790 kPa (2000 psig) class or 20,685 kPa (3000 psig) class. Use Schedule 80 pipe and fittings for threaded joints.

F. Flanges: Forged steel weld neck, ASTM A105/A105M, ASME B16.5, 1034 kPa (150 psig).

2.3 FUEL PIPING

A. Natural gas, LP gas (propane), fuel oil (No. 2 heated) for main burner and igniter (pilot) fuels, gas vent piping. Comply with ASME B3l.l and NFPA 54.

B. Piping: Carbon steel, ASTM A53/A53M Grade B or ASTM A106/A106M Grade B, seamless or ERW, Schedule 40. Fuel oil piping shall be seamless downstream of burner automatic shutoff valves.

C. Joints:

1. Pipe sizes 65 mm (2-1/2 inches) and above: Butt-welded, no other types allowed.
2. Pipe sizes 50 mm (2 inches) and below: Socket-welded or butt-welded.

D. Fittings:
   1. Butt-welded joints: Steel, ASTM A234/A234M, Grade B, ASME B16.9, same schedule as adjoining pipe.
   2. Socket-welded joints: Forged steel, ASME B16.ll, 13,790 kPa (2000 psig class.
E. Unions on piping 50 mm (2 inches) and under: Forged steel, 13,790 kPa (2000 psig) class or 20,685 kPa (3000 psig) class.
F. Flanges: Forged steel weld neck, ASME B16.5, ASTM A105/A105M, 1034 kPa (150 psig).
G. Companion flanges: Flanges and bolting shall conform to ASME B16.5.
H. Burner Piping: Furnished as part of the factory-assembled burners may be manufacturer's standard materials and assembly. Comply with ASME B31.1, for the actual operating conditions.
I. Igniter (Pilot) Piping: Furnished as part of the factory assembled burners may have 2070 kPa (300 psig) ASTM A47/A47M, ASME B16.3 malleable iron threaded fittings in lieu of welded steel. If threaded fittings are provided, piping shall be Schedule 80.

2.4 BOILER FEEDWATER PIPING

A. Piping from boiler feedwater pump discharge to inlet of boilers.
B. Pipe: Carbon steel, ASTM A53/A53M Grade B or ASTM A106/A106M Grade B, seamless or ERW. Piping with threaded joints shall be Schedule 80; welded joints Schedule 40. No joining of different schedule pipe in order to have welded on one end and threaded on the other. In these cases, the length of pipe shall be Schedule 80.
C. Joints:
   1. Pipe sizes 65 mm (2-1/2 inches) and above: Butt-welded, no other types are allowed.
   2. Pipe sizes 50 mm (two inches) and below: Threaded, butt-welded, or socket-welded.
   3. No pipe to pipe joints when the length of the run is less than a full length of pipe.
D. Fittings:
   1. Butt-welded Joints: Steel, ASTM A234/A234M, Grade B, ASME B16.9, same schedule as adjoining pipe.
   2. Threaded Joints: Forged steel, ASME B16.ll, 13,790 kPa (2000 psig class. Use Schedule 80 pipe and fittings for threaded joints.

3. Socket-welded joints: Forged steel, ASME B16.11, 13,790 kPa (2000 psig) class.

E. Unions: Forged steel, 13,790 kPa (2000 psig) class or 20,685 kPa (3000 psig) class.

F. Flanges and Bolts: Forged steel weld neck, ASME B16.5, ASTM A105/A105M, 2070 kPa (300 psig) pressure class. Bolts shall be High strength ASTM A193/A193M, Class 2, Grade B7. Nuts shall be ASTM A194/A194M.

2.5 BOILER BLOWOFF PIPING

A. From boiler bottom blowoff connection to blowoff tank. Connections between boiler accessories drain valves and blowoff lines.

B. Pipe: Carbon steel, ASTM A106/A106M, Grade B, seamless, Schedule 80.

C. Joints: Butt-welded, no other types are allowed.

D. Fittings: Steel, ASTM A234/A234M, Grade B, ASME B16.9, same schedule as adjoining pipe, all elbows long radius. Tees or crosses are prohibited.

E. Flanges: Forged steel weld neck, ASME B16.5, ASTM A105/A105M, 2070 kPa (300 psig).

F. At no point shall the bottom blow down lines rise above the point of connection to the boiler.

2.6 DRAIN PIPING FROM BOILER ACCESSORIES TO DRAIN VALVE

A. Drain piping from water column, low water cutoffs, gauge glass, water level sensor, remote water level devices (where applied).

B. Pipe: Carbon steel, ASTM A106/A106M, seamless, Schedule 40.

C. Joints: Threaded.

D. Fittings: Forged steel, ASME B16.ll, 13,790 kPa (2000 psig) class.

E. Unions: Forged steel, 13,790 kPa (2000 psig) class or 20,685 kPa (3000 psig) class.

2.7 VENT LINES FROM TANKS AND SAFETY AND RELIEF VALVES

A. Pipe: Carbon steel, ASTM A53/A53M Grade B or A106/A106M Grade B, seamless or ERW, Schedule 40.

B. Joints:

1. Pipe sizes 65 mm (2-l/2 inches) and above: Butt-welded, no other types are allowed.
2. Pipe sizes 50 mm (2 inches) and below: Threaded or butt-welded.

C. Fittings:

1. Welded Joints: Steel, ASTM A234/A234M, Grade B, ASME B16.9, same schedule as adjoining pipe.

2. Threaded Joints: Steel, ASTM A234/A234M, Grade B, ASME B16.9, Schedule 80.

D. Unions: Forged steel, 13,790 kPa (2000 psig) class or 20,685 kPa (3000 psig) class.

E. Flanges: Forged steel weld neck, ASME B16.5, ASTM A105/A105M, 1034 kPa (150 psig).

2.8 COLD WATER PIPING

A. Soft Water: See Section 22 31 11, WATER SOFTENERS.

B. City Water: See Section 22 11 00, FACILITY WATER DISTRIBUTION.

C. All copper pipe shall use only soldered fittings.

2.9 REVERSE OSMOSIS WATER PIPING

A. See Section 22 67 19.16, REVERSE OSMOSIS WATER EQUIPMENT.

B. All reverse osmosis piping in the boiler plant shall be stainless steel with all valves, etc. made of stainless steel. At no point shall the reverse osmosis water come into direct contact with carbon steel pipe or equipment.

2.10 COMPRESSED AIR PIPING (FUEL OIL ATOMIZING SERVICE)

A. Pipe: Carbon steel, ASTM A53/A53M Grade B or ASTM A106/A106M Grade B, seamless or ERW Schedule 40.

B. Joints: Threaded.

C. Fittings: Forged steel, ASME B16.ll, 13,790 kPa (2000 psig class); or malleable iron ASTM A47/A47M or ASTM A197/A197M, ASME Bl6.3, 1034 kPa (150 psig) class.

D. Unions: Forged steel, 13,790 kPa (2000 psig) class or 20,685 kPa (3000 psig) class; or malleable iron, 1034 kPa (150 psig) class.

2.11 BOILER WATER SAMPLING, CONTINUOUS BLOWDOWN

A. Pipe: Steel, ASTM A106/A106M Grade B, seamless, Schedule 80.

B. Joints: Threaded.

C. Fittings: Forged steel, ASME B16.ll, 13,790 kPa (2000 psig) class. Fittings between boiler and first stop valve must be forged steel, ASME B16.11, 13,790 kPa (2000 psig) or 20,685 kPa (3000 psig) class.

D. Unions: Malleable iron, 2070 kPa (300 psig) class.

2.12 FEEDWATER SAMPLING AND CHEMICAL FEED PIPING

A. Pipe: Stainless steel tubing, ASTM A269/A269M, Type 316.

B. Fittings: Stainless steel Type 316 welding fittings.

2.13 MISCELLANEOUS PIPING

A. Instrument and Control Piping (Sensing Point to Transmitter, Controller, or Other Instrument): Construction shall be same as specified for main service.

B. Drain Piping (All Drain Piping Discharging to Floor Drain-From Drain Valve to Floor Drain):

1. Pipe: Carbon steel, ASTM A53/A53M Grade B or ASTM A106/A106M Grade B, seamless or ERW, Schedule 40.
2. Fittings and Unions: Forged steel, ASME B16.11, 13,790 kPa (2000 psig class); or malleable iron, 1034 kPa (150 psig), threaded.

C. Pump Recirculation:

1. Pipe: Carbon steel, ASTM A53/A53M Grade B or ASTM A106/A106M Grade B, seamless or ERW, double extra strong. Schedule 40 permitted on all lines 1500 mm (5 feet) or more from the recirculation orifice.
2. Joints: Threaded.
3. Fittings: Forged steel, ASME B16.11, 13,790 kPa (2000 psig) class; or malleable iron, ASTM A47/A47M or ASTM A197/A197M, ASME B16.3, 2070 kPa (300 psig) class, except 1034 kPa (150 psig) class permitted on all lines 1500 mm (5 feet) or more from the recirculation orifice.
4. Unions: Forged steel, 13,790 kPa (2000 psig) class or 20,685 kPa (3000 psig) class; or malleable iron, ASTM A47/A47M or ASTM A197/A197M, same pressure class as nearest fittings.

2.14 DIELECTRIC FITTINGS

A. Provide threaded dielectric unions for pipe sizes 50 mm (2 inches) and under. For 65 mm (2-1/2 inches) and above, provide steel flanges electrically isolated at gasket and by sleeves at bolts. Fittings on cold water and soft water lines shall be rated for 690 kPa (100 psig), 27 degrees C (80 degrees F). Fittings on steam condensate lines shall be rated at 520 kPa (75 psig), 121 degrees C (250 degrees F). Fittings on other services shall be rated for the maximum pressure and temperature conditions of the service.

2.15 VALVES; GATE, GLOBE, PLUG, CHECK, BALL, BUTTERFLY, VENT COCKS

A. Valves for particular services are generally specified as Type Numbers. The Type Numbers are defined below. All valves of the same type shall be the products of a single manufacturer. Comply with MSS SP-45, MSS

SP-80, and ASME B31.1. Design valves for the service fluids and conditions. Pressure-temperature ratings listed are minimum requirements. Packing and gaskets shall not contain asbestos.

B. Valve Type Designations:
   1. Gate Valves:
      a. Type 101: Cast steel body ASTM A216/A216M WCB, rated for 1034 kPa at 260 degrees C (150 psig at 500 degrees F), 11.5 to 13 percent chromium stainless steel flexible wedge and hard faced (stellite) or nickel copper alloy seats, 1034 kPa (150 psig) ASME flanged ends, OS&Y, rising stem, bolted bonnet.
         1) Provide factory installed globe-valved warm-up bypass when main valve is 75 mm (3 inch) pipe size or greater and serves steam main longer than 6.1 m (20 feet). Conform to MSS SP-45.
         2) Drill and tap bosses for connection of drains if valve is in steam service. Conform to MSS SP-45.
      b. Type 102: Cast steel body ASTM A216/A216M WCB, Class 300, 11.5 to 13 percent chromium stainless steel flexible wedge and hard faced (stellite) alloy seats, ASME flanged ends, OS&Y, rising stem, and bolted bonnet.
         1) Provide factory installed globe-valved bypass when main valve is 75 mm (3 inch) pipe size or greater and serves steam main longer than 6.1 m (20 feet). Conform to MSS SP-45.
         2) Drill and tap bosses for connection of drains if valve is in steam service. Conform to MSS SP-45.
      c. Type 103: Cast steel body ASTM A216/A216M WCB, Class 300, 11.5 to 13 percent chromium stainless steel flexible wedge and hard faced (stellite) alloy seats, ASME flanged ends, OS&Y, rising stem, and bolted bonnet.
         1) Provide factory installed globe-valved bypass when main valve is 75 mm (3 inch) pipe size or greater and serves steam main longer than 6.1 m (20 feet). Conform to MSS SP-45.
         2) Drill and tap bosses for connection of drains if valve is in steam service. Conform to MSS SP-45.
      d. Type 105: Forged steel body ASTM A105/A105M, rated for 2070 kPa at 216 degrees C (300 psig at 420 degrees F) minimum, Class 4138 kPa (600 psig) or Class 5515 kPa (800 psig), hardened stainless

steel or stellite wedge and seats, threaded ends, OS&Y, rising stem, bolted bonnet.

2. Globe Valves:
   a. Type 201: Cast steel body ASTM A216/A216M WCB, rated for 1034 kPa at 260 degrees C (150 psig at 500 degrees F), 11-1/2 to 13 percent chromium stainless steel or stellite disc and seat, 1034 kPa (150 psig) ASME flanged ends, OS&Y, rising stem, bolted bonnet, renewable seat rings. Drill and tap bosses for connection of drains where shown. Conform to MSS SP-45.
   b. Type 205: Forged steel body ASTM A105/A105M, rated for 2070 kPa at 216 degrees C (300 psig at 420 degrees F) minimum, Class 4138 kPa (600 psig) or Class 5515 kPa (800 psig), stainless steel disc, stellite seat, threaded ends, OS&Y, rising stem, bolted bonnet.
3. Plug Valves: Cast steel body ASME B16.5 Class 150, one-fourth turn to open. 861 kPa (125 psig) ASME flanged ends for pipe sizes above 50 mm (2 inches), threaded ends for pipe sizes 50 mm (2 inches) and under. All components designed for service to which applied: natural gas, LP gas (propane), or fuel oil. Furnish lever handle for each valve.
   a. Type 301: Two-way valves up through 100 mm (4 inches) pipe size. Eccentric action, non-lubricated plug with resilient seal molded into groove on plug face providing bubble-tight shut off. O-ring stem seal, corrosion-resistant bearings, corrosion-resistant seat coating, seal materials as recommended by valve manufacturer for the service. Valves on natural gas service AGA approved.
   b. Type 302: Two-way valves 125 mm (5 inches) pipe size and above, all sizes of three-way valves. Lubricated full-port plug type with lubricant for intended service. Reinforced Teflon stem seal, valve plug floated on Teflon surfaces, lubricant injection system that has sufficient pressure to fully lubricate all sealing surfaces. Provide laminated plastic label attached to each valve stating, “Lubricate with manufacturer’s recommendation for service used once a year”.
4. Check Valves:
   a. Type 401: Not used.

b. Type 402: Swing-type, cast steel body ASME B16.34, rated for 1724 kPa (250 psig) saturated steam, 3447 kPa (500 psig) WOG, bronze or bronze-faced disc and seat, 1724 kPa (250 psig) ASME flanged ends, bolted cover, renewable disc and seat.

c. Type 403: Swing-type, cast steel body ASME B16.34, rated for 861 kPa (l25 psig) saturated steam, 1380 kPa (200 psig) WOG, bronze or bronze-faced disc and seat, 861 kPa (l25 psig) ASME flanged ends, bolted cover, renewable disc and seat.

d. Type 405: Lift-type, forged steel body ASTM A105/A105M, rated for 2070 kPa at 216 degrees C (300 psig at 420 degrees F) minimum (Class 4138 kPa (600 psig) or 5515 kPa (800 psig)), hardened stainless steel disc, hard faced seat, bolted cover, threaded ends.

e. Type 406: Swing-type, Type 316 stainless steel body, disc and hanger, rated for 1724 kPa at 182 degrees C (250 psig at 360 degrees F) minimum.

f. Type 408: Silent spring-loaded wafer type, cast steel ASTM A216/A216M WCB body, rated for 2070 kPa (300 psig) water, 121 degrees C (250 degrees F), stainless steel trim.

5. Ball Valves: Reduced port permitted for bypass (throttling) service; full port required for all other services, one-fourth turn to open.

a. Type 501: Type 316 stainless steel body, ball and stem, rated for 1034 kPa at 185 degrees C (150 psig at 365 degrees F), 4138 kPa at 93 degrees C (600 psig at 200 degrees F); reinforced TFE seat, stem seal and thrust washer; end entry, threaded ends.

b. Type 502: Steel body, rated for 1034 kPa at 185 degrees C (150 psig at 365 degrees F), 1724 kPa at 121 degrees C (250 psig at 250 degrees F), reinforced TFE seat, stem seal and thrust washer; end entry, threaded ends, UL-listed for natural or LP gas shut off service when used on those services.

c. Type 503: Carbon steel body, steam service, rated for 1380 kPa at 200 degrees C (200 psig at 392 degrees F), stainless steel ball and stem, Polyfil seat, live-loaded or adjustable stem seal, threaded ends.

d. Type 504: Carbon steel body, saturated steam service, rated for 1034 kPa (150 psig), stainless steel ball and stem, Polyfil seat, live-loaded stem seal, ASME flanged ends.

6. Butterfly Valves:
   a. Type 601: Carbon steel ASTM A216/A216M wafer style, rated for 861 kPa at 121 degrees C (125 psig at 250 degrees F), bronze disc, stainless steel stem, EPDM liner, EPDM stem seal and body seal, neck extending beyond pipe insulation, lever operator.
   b. Type 602: Carbon steel body, triple-offset design, lug or flanged type, rated for steam service at 1034 kPa at 260 degrees C (150 psig at 500 degrees F), stainless steel nitrided disc, stainless steel seat, stainless steel shaft, stainless steel/graphite laminated seal ring, neck extending beyond pipe insulation, geared handwheel operator for valves 100 mm (4 inch) pipe size and over, lever operator for valves 75 mm (3 inch) pipe size and under.
7. Gas Vent Cocks: Type 701, bronze body, tee handle, rated for 207 kPa at 38 degrees C (30 psig at 100 degrees F), ground plug, rated for tight shut-off on fuel gas service.

C. Boiler Valves:
1. Steam Non-Return Stop Check Valves:
   a. Type: Straight-way Y-pattern, with dash-pot and piston and tapped drain openings, OS&Y, bolted bonnet, rising stem. Provide angle pattern only if shown on the contract drawings.
   b. Construction: Cast steel body ASTM A216/A216M WCB, rated for 2070 kPa (300 psig) saturated steam, stellite faced steel disc, alloy steel seat, 2070 kPa (300 psig) ASME flanged ends.
   c. Operation: Valves shall automatically close tightly when boiler steam pressure becomes less than that of the steam header. Valves shall operate without sticking or chattering.
2. Stop Valves for Steam Vents on Boiler Drums and Steam Lead, Steam Pressure Gauge:
   a. Installation of steam pressure gauge shut-off valves shall conform to ASME BPVC, Section I.

b. Angle stop valves (water tube boilers), OS&Y, chain operated, cast or forged steel, 1380 kPa (200 psig) steam rating, renewable seat and disc.
c. Gate valves, two inches and under: Type 105.

3. Valves in Drain Lines from Steam Stop Check Valve, Water Column, Gauge Glass, Low Water Cut-offs:
   a. Gate valves, two inches and under: Type 105.
   b. Check valves, two inches and under: Type 405.
4. Bottom Blowoff Valves:
   a. gned for blowoff service. Sliding disc-type or globe-type valves are prohibited.
   b. Construction: ASTM A216/A216M WCB cast steel body, rated for 2070 kPa (300 psig) saturated steam, 2070 kPa (300 psig) ANSI flanged ends. Valves shall have handwheel with rotating handle.
   c. Conform to ASME B31.1.

D. Steam above 103 kPa (15 psig), all valves in steam pressure reducing stations:
   1. Gate valves, 50 mm (2 inches) and under: Type 105.
   2. Gate valves, 65 mm (2-1/2 inches) and above: Type 101.
   3. Globe valves, 50 mm (2 inches) and under: Type 205.
   4. Globe valves, 65 mm (2-1/2 inches) and above: Type 201.
   5. Butterfly valves, 75 mm (3 inches) and above: Type 602.
   6. Ball valves, 50 mm (2 inches) and under: Type 503.
   7. Ball valves, 65 mm (2-1/2 inches) and above: Type 504.

E. Steam 103 kPa (15 psig) and under:
   1. Gate Valves, 50 mm (2 inches) and under: Type 105.
   2. Gate valves, 65 mm (2-1/2 inches) and above: Type 103.
   3. Globe valves, 50 mm (2 inches) and under: Type 205.
   4. Globe valves, 65 mm (2-1/2 inches) and above: Type 205.
   5. Butterfly valves, 75 mm (3 inches) and above: Type 602.
   6. Ball valves, 50 mm (2 inches) and under: Type 503.
   7. Ball valves, 65 mm (2-1/2 inches) and above: Type 504.

F. Boiler Feedwater from Pumps to Boilers, Recirculation:
   1. Gate valves, 50 mm (2 inches) and under: Type 105.
   2. Gate valves, 65 mm (2-1/2 inches) and above: Type 102.
   3. Globe valves, 50 mm (2 inches) and under: Type 205.

4. Globe valves, 65 mm (2-l/2 inches) and above: Type 205.
5. Check valves, at boiler feed pump discharge: Type 408.
6. Check valves, at boiler, 50 mm (2 inches) and under: Type 405.
7. Check valves, at boiler, 65 mm (2-1/2 inches) and above: Type 402.

G. Condensate, Condensate Transfer, Boiler Feedwater from Feedwater Deaerator to Boiler Feed Pump Suction, Overflow, Control and Instrument Piping for Condensate Storage Tank and for Feedwater Deaerator:

1. Gate valves, 50 mm (2 inches) and under: Type 105.
2. Gate valves, 65 mm (2-1/2 inches) and above: Type 103.
3. Globe valves, 50 mm (2 inches) and under: Type 205.
4. Globe valves, 65 mm (2-1/2 inches) and above: Type 205.
5. Butterfly valves, 65 mm (2-1/2 inches) and above Type 601.
6. Ball valves, 50 mm (2 inches) and under: Type 502.
7. Ball valves, 65 mm (2-1/2 inches) and above: Type 504.
8. Check valves 50 mm (2 inches) and under: Type 405.
9. Check valves, 65 mm (2-1/2) inches and above: Type 403.
10. Check valves on pump discharge, all sizes: Type 408.

H. Boiler Water Sampling, Continuous Blowdown:

1. Gate Valves, 50 mm (2 inches) and under: Type 105.
2. Globe valves, 50 mm (2 inches) and under: Type 205.
3. Check valves, 50 mm (2 inches) and under: Type 405.
4. Ball valves, 50 mm (2 inches) and under: Type 502.
5. Continuous Blowdown Flow Control Valve: Forged steel angle-type body, rated for 2070 kPa at 288 degrees C (300 psig at 550 degrees F), hardened stainless steel disc and seat, threaded ends, rising stem, union bonnet, graduated micrometer-type dial and pointer showing amount of valve opening. Furnish valve blowdown chart showing flow rate versus valve opening based on 861 kPa (125 psig) boiler drum pressure.

I. Feedwater Sampling:

1. Ball valves, 50 mm (2 inches) and under: Type 501.
2. Check valves, 50 mm (2 inches) and under: Type 406.

J. Chemical Feed System:

1. Ball valves, 50 mm (2 inches) and under: Type 501.
2. Check valves, 50 mm (2 inches) and under: Type 406.

K. Fuel Oil: Discharge side of pumps. Conform to NFPA 30 and NFPA 31.
   1. Gate valves, 50 mm (2 inches) and under: Type 105.
   2. Gate Valves, 65 mm (2-1/2 inches) and above: Type 101 or 102.
   3. Globe valves, 50 mm (2 inches) and under: Type 205.
   4. Plug valves, 100 mm (4 inches) and under: Type 301. (Tank isolating valve on return line.)
   5. Check valves, 50 mm (2 inches) and under: Type 405 or 408.
   6. Check valves, 65 mm (2-1/2 inches) and above: Type 402 or 408.
   7. Ball valves, 50 mm (2 inches) and under: Type 502.

L. Fuel Oil: Suction side of pumps and tank fill lines where tank is below fill point. Conform to NFPA 30 and NFPA 31.
   1. Gate valves, 50 mm (2 inches) and under: Type 105.
   2. Gate valves, 65 mm (2-1/2 inches) and above: Type 103.
   3. Plug valves, 100 mm (4 inches) and under: Type 301.
   4. Check valves, 50 mm (2 inches) and under: Type 405.
   5. Check valves, 65 mm (2-1/2 inches) and above: Type 403.
   6. Ball valves, 50 mm (2 inches) and under: Type 502.

M. Fuel Oil: Tank fill lines where tank is above fill point.
   1. Gate valves, 50 mm (2 inches) and under: Type 105.
   2. Gate valves, 65 mm (2-1/2 inches) and above: Type 103.
   3. Check valves, all sizes: Type 408.

N. Fuel Gas: Main fuel and igniter (pilot) systems.
   1. Plug valves, 100 mm (4 inches) and under: Type 301.
   2. Ball valves, 50 mm (2 inches) and under: Type 502. May be applied where plug valves are shown.
   3. Plug valves, 125 mm (5 inches) and above: Type 302.
   4. Plug valves, three-way, all sizes: Type 302.
   5. Check valves, 50 mm (2 inches) and under: Type 405.
   6. Vent cocks, 15 mm (1/2 inch) and under: Type 701.

O. Compressed Air:
   1. Gate valves, 50 mm (2 inches) and under: Type 105.
   2. Ball valves, 50 mm (2 inches) and under: Type 502.

P. City (Cold) Water: See Section 22 11 00, FACILITY WATER DISTRIBUTION.

Q. Soft Water: See Section 22 31 11, WATER SOFTENERS.

R. Instrumentation and Control Piping: Ball valves, 50 mm (2 inches) and under: Type 502.

S. Non-Boiler Blowdowns, Drains, Flow Sensing Lines:
   1. Gate valves, 50 mm (2 inches) and under: Type 105.
   2. Ball valves, 50 mm (2 inches) and under: Type 503.

2.16 GAUGES, PRESSURE AND COMPOUND

A. ASME B40.100, 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 steel, lever handle union cock. Provide steel or stainless-steel pressure snubber for gauges in water service. Provide steel pigtail syphon for steam gauges.

C. Pressure gauge ranges shall be selected such that the normal operating pressure for each gauge is displayed near the midpoint of each gauge’s range. Gauges with ranges selected such that the normal pressure is displayed at less than 30 percent or more than 70 percent of the gauge’s range are prohibited. The units of pressure shall be kPa psig.

2.17 SIGHT FLOW INDICATORS

A. Provide, where shown, to allow observation of flow in piping systems.

B. Type: In line, dual portholes on opposite sides, with safety shield, with or without rotor as shown on the drawings. Where provided, rotor shall have minimum of three vanes.

C. Construction: Carbon steel body, tempered borosilicate window, PTFE seals (except Buna-N on oil service), threaded ends on pipe sizes under 65 mm (2-1/2 inches), flanged ends on sizes 65 mm (2-1/2 inches) and above. Pressure and temperature ratings shall be equivalent to requirements for valves on the same pipelines.

D. Safety Shield: Transparent wrap-around overlap covering entire sight flow indicator, designed to protect personnel from failure of indicator. Shield shall fit the indicator tightly and be suitable for 1034 kPa, 150 degrees C (150 psig, 302 degrees F).

2.18 QUICK-COUPLE HOSE CONNECTORS AND STEAM HOSES

A. Provide on all Y-strainer drains and where shown to allow quick connection of length of hose to piping drain or blowoff so that discharge fluid (water or steam) can be conveyed to a drainage system.

B. Type: Straight through, plug and socket, screw type or cam locking connections, all units 20 mm (3/4 inch) pipe size. Integral shut-off devices not required.

C. Service: Design for water and steam at 103 kPa (15 psig), 154 degrees C (309 degrees F).

D. Spare Parts: Furnish one socket and one plug.

E. Accessories: Furnish two hoses 6.1 m (20 feet) long, 20 mm (3/4 inch) inside diameter, rated for steam service at 690 kPa, 149 degrees C (100 psig, 300 degrees F). Hose must be sufficiently flexible to be placed in 1200 mm (4 foot) diameter coil. Provide connector on one end of each hose to mate with connectors on drains. Provide hose rack for holding both hoses. Securely mount rack in location selected by COR.

2.19 SAFETY VALVES, RELIEF VALVES, SAFETY RELIEF VALVES AND ACCESSORIES

A. Provide valves and accessories to protect piping systems and pressure vessels from over-pressure. All valves shall comply with ASME BPVC Section I and ASME BPVC Section VIII). Flow capacities shall be certified by National Board of Boiler and Pressure Vessel Inspectors (NB).

B. Steam Service (Pressure Vessels and Piping Systems): Refer to schedules on drawings for set pressures and capacities. Provide lifting levers, stainless steel trim, lapped seats on steel valves.

C. Fuel Oil Service: Refer to Section 23 50 11, BOILER PLANT MECHANICAL EQUIPMENT.

D. Compressed Air Service: Refer to Section 23 50 11, BOILER PLANT MECHANICAL EQUIPMENT.

E. Drip Pan Ells: Cast iron factory-built safety valve discharge fitting with pipe-within-pipe slip-type connection to vertical vent pipe, basin for collecting condensate from vent pipe, drain connections on basin and at base of ell.

2.20 STEAM PRESSURE REDUCING VALVES

A. Type: Single-seated, diaphragm operated, spring-loaded, steam pilot-controlled, normally closed, packless, adjustable set pressure. Pilot shall sense controlled pressure downstream of main valve.

B. Service: Provide controlled reduced pressure to steam piping systems. Design for saturated steam at pressures shown on drawings or equipment requirements.

C. Performance: Pressure control shall be smooth, continuous. Maximum percent deviation from set pressure over an 10/1 turndown. Refer to schedules on drawings for flow and pressure requirements. Downstream safety valve shall be sized equal to or exceed the maximum total flow capacity of the pressure reducing station.

D. Construction:

1. Main Valve – Pipe sizes 50 mm (2 inches) and less: Steel body rated for 1724 kPa (250 psig), threaded ends. Globe body valve and seat shall be replaceable, Type 316 stainless steel and include stainless steel stem.
2. Main Valves – Pipe sizes greater than 50 mm (2 Inches): Steel body rated for 1034 kPa (150 psig), ASME flanged ends, or steel body 1724 kPa (250 psig) ASME flanged ends. Globe body valve and seat shall be replaceable, Type 316 stainless steel and include stainless steel stem.
3. Pilot Valve: Valve plug and seat shall be replaceable, stainless steel or Monel.

E. Direct Digital Control Valves: May be furnished in lieu of steam operation. All specification requirements for steam operated valves shall apply. In the event of signal failure, failsafe device accessory in the actuator to stroke valve to predetermined position indicated. Install per manufacturer’s recommendation.

F. Sound Levels: Refer to requirements in Section 23 05 51, NOISE AND VIBRATION CONTROL FOR BOILER PLANT.

2.21 STRAINERS, SIMPLEX BASKET TYPE

A. Provide on condensate lines where shown. Refer to Section 23 50 11, BOILER PLANT MECHANICAL EQUIPMENT, for duplex basket strainers at oil pumps.

B. Type: Simplex cylindrical basket type, clamp cover, closed-bottom, removable basket, drain at bottom with threaded plug.

C. Service: Water at 100 degrees C (212 degrees F), 103 kPa (15 psig) maximum pressure.

D. Construction:

1. Body: Cast steel rated for 861 kPa (125 psig) ASME flanged ends, flow arrows cast on side.

2. Basket: Stainless steel, 3.2 mm (1/8 inch) perforations. Ratio of screen open area to cross section of pipe; four to one minimum.

2.22 STRAINERS, Y-TYPE

A. Provide as shown on steam, water and compressed air piping systems.

B. Type: Open-end removable cylindrical screen. Threaded blow-off connection.

C. Construction:

1. Steam Service 420 to 1034 kPa (61 to 150 psig): Cast steel rated for 1034 kPa (150 psig) saturated steam with 1034 kPa (150 psig) ASME flanged ends, or forged steel with 1724 kPa (250 psig) ASME flanged ends, for pipe sizes above 50 mm (2 inches). Cast steel rated for saturated steam at 1034 kPa (150 psig) threaded ends, for pipe sizes 50 mm (2 inches) and under.

2. Steam Service 414 kPa (60 psig) and under, water (except boiler feed between feedwater pumps and boilers), compressed air: Cast steel rated for 861 kPa (125 psig) saturated steam, 1200 kPa (175 psig) WOG, with 861 kPa (125 psig) ASME flanged ends, for pipe sizes above 50 mm (2 inches). Cast steel, threaded ends, rated for 861 kPa (125 psig) saturated steam, 1200 kPa (175 psig) WOG, for pipe sizes 50 mm (2 inches) and under.

3. Boiler Feed between Feedwater Pumps and Boilers: Cast steel rated for 1724 kPa at 232 degrees C (250 psig at 450 degrees F) with 2070 kPa (300 psig) ASME flanged ends or cast steel with 1724 kPa (250 psig) ASME flanged ends, for pipe sizes above 50 mm (2 inches). Cast steel, threaded ends, rated for 1724 kPa at 232 degrees F (250 psig at 450 degrees F) for pipe sizes 50 mm (2 inches) and under.

D. Screen: Monel or stainless steel, free area not less than 2-1/2 times flow area of pipe. For strainers 75 mm (3 inch) pipe size and smaller, diameter of openings shall be 0.8 mm (0.032 inch) or less on steam service, 1.3 mm (0.05 inch) or less on water service, 0.3 mm (0.01 inch) or less on compressed air service. For strainers 100 mm (4 inch) pipe size and greater, diameter of openings shall be 1.3 mm (0.05 inch) on steam service, 3.2 mm (1/8 inch) on water service. Provide 80 mesh stainless steel screen liner on all strainers installed upstream of water meters or control valves.

E. Accessories: Gate or ball valve and quick-couple hose connection on all blowoff connections. These items are specified elsewhere in this section.

2.23 LIQUID PETROLEUM TANKS GAS PRESSURE REGULATORS

A. Type: Single stage or two-stage designed to reduce tank pressure to LPG header pressure 34 kPa (5 psig). Outlet pressure shall be adjustable. Design for LPG (propane) service. Valve shall be weatherproof for outside installation. Valve body shall be designed for 1724 kPa (250 psig). Provide internal relief valve set at 69 kPa (10 psig).

B. Performance: Valve shall provide steady outlet pressure of 34 kPa (5 psig) with flow rate required by igniters (pilots) furnished, with tank pressure variation from 1724 kPa to 138 kPa (250 psig to 20 psig).

2.24 EMERGENCY GAS SAFETY SHUT-OFF VALVE WITH EARTHQUAKE SENSOR

A. Permits remote shut-off of fuel gas flow to boiler plant.

B. Type: Manually opened, electrically held open, automatic closing upon power interruption. Pneumatic operator is prohibited.

C. Performance: Shall shut bubble tight within one second after power interruption. Refer to the drawings for pressure, flow, and valve size requirements.

D. Service: Natural gas and LP gas.

E. Construction: UL listed, FM approved, rated for 861 kPa (125 psig) ASME flanged ends for pipe sizes above 50 mm (2 inches), threaded ends for pipe sizes 50 mm (2 inches) and under. Cast iron, cast steel or bronze body, open and shut indicator. Valves for LP gas service shall be rated at 1724 kPa (250 psig).

F. Control Switch: Mounted on Boiler Plant Instrumentation Panel in Control Room and at exterior doorways (multiple switches). Switch shall also cut the power to the boiler fuel oil pump set. Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT. Provide auxiliary switch to operate annunciator on Boiler Plant Instrumentation Panel and provide signal to Computer Work Station.

G. Earthquake Sensor: Mechanical device which automatically breaks 120-volt electrical circuit to safety shut off valve when earthquake occurs allowing valve to automatically close. UL listed and shall comply with CRSC Title 24 Part 12. Valve shall close within 5 seconds after sensor is subjected to horizontal sinusoidal oscillation having a peak acceleration of 2.94 m/sec^2 (0.3g) and a period of 0.4 seconds. The valve shall not shut off when the sensor is subjected for 5 seconds to horizontal, sinusoidal oscillations having: a peak acceleration of 3.92 m/sec^2 (0.4g) with a period of 0.1 second; a peak acceleration of 0.78 m/sec^2 (0.08g) with a period of 0.4 second; peak acceleration of 0.78 m/sec^2 (0.08g) with a period of 1.0 second. Sensor shall be corrosion-resistant for outside location. Manufacturer: Quake-Defense or equal.

2.25 EARTHQUAKE AUTOMATIC GAS SHUT OFF VALVE

A. Automatically stops gas flow to boiler plant when actuated by earth tremor.

B. Type: Single seated, manual reset.

C. Performance: Shall automatically shut bubble tight within five seconds when subjected to a horizontal sinusoidal oscillation having a peak acceleration of 2.94 m/sec^2 (0.3g) and a period of 0.4 seconds. The valve shall not shut-off when subjected for five seconds to horizontal, sinusoidal oscillations having: A peak acceleration of 3.92 m/sec^2 (0.4g) with a period of 0.1 second; a peak acceleration of 0.78 m/sec^2 (0.08g) with a period of 0.4 second or 1.0 second. Refer to drawings for pressure, flow and valve size requirements.

D. Service: Natural gas or LP gas.

E. Construction: 138 kPa (20 psig) minimum rating. Cast iron or aluminum body, rated for 861 kPa (125 psig) ASME flanged ends for pipe sizes above 50 mm (2 inches). Threaded ends for pipe sizes 50 mm (2 inches) and under. Valves for LP gas service shall be rated at 1724 kPa (250 psig).

F. Approvals: UL listed, State of California Referenced Standards Code for Earthquake Actuated Automatic Gas Shut-off Systems. Complies with ASCE 25.

G. Nitrile rubber, reset stem O-ring seal.

H. Valve position indication, open or closed indicators.

2.26 STEAM TRAPS

A. Application: Steam line drip points and heat exchangers. Each type furnished by a single manufacturer.

B. Type: Inverted bucket type with thermostatic vent in bucket except closed float-thermostatic on discharge side of pressure reducing stations and on all heat exchangers. Refer to the drawings for trap locations, capacity and size, differential operating pressures, and design pressure.

C. Trap bodies: Steel, constructed to permit ease of removal and servicing working parts without disturbing connecting piping. The use of raised face flange is required on pipe sizes 1½ inch and above. The use of unions is acceptable for pipe sizes below 1½ inches. For systems without relief valve traps shall be rated for the pressure upstream of the steam supplying the system.
D. Floats: Stainless steel.
E. Valves: Hardened chrome-steel.
F. Mechanism and Thermostatic Elements: Stainless steel mechanisms. Bimetallic strip air vent on inverted bucket traps.
G. Provision for Future Trap Monitoring System: All traps shall include ports for future installation of monitoring devices. Ports shall be plugged. To facilitate future removal of the plugs, install them with Teflon tape on the threads.
H. Identification: Label each trap at the factory with an identification number keyed to number that is shown on the drawings. Label shall be a metal tag permanently affixed to the trap.
I. Factory-Packaged Trap Station: As an option for drip points requiring isolating valves, strainer, trap, trap monitoring device or ports for future monitoring device, and valved test ports, provide factory-packaged trap station including these features.

2.27 PRESSURE DRIVEN CONDENSATE PUMP TRAP

A. Unit shall automatically trap and pump condensate from process and heating equipment under all operating conditions including vacuum.
B. Body shall be constructed of carbon steel with all stainless-steel internals. The mechanism shall incorporate Inconel alloy springs.
C. Motive Force: The pump trap shall utilize steam, compressed air or inert gas to remove condensate from the receiving vessel. If two types of motive forces are used (e.g., primary and back-up force) the two systems shall never be permanently interconnected.
D. Pumps shall require no electricity for operation.

E. The pump trap shall include a carbon steel water level gauge with shut off valves.

F. Check valves at inlet and outlet shall be stainless steel.

G. ASME BPVC Section VIII.

H. Provide Pump Trap with removable insulation cove and digital cycle counter.

I. Manufacturer standard paint finish .

2.28 FLEXIBLE CONNECTORS

A. Provide flexible connectors as shown to allow differential movements of pumps and piping systems subject to thermal expansion, to serve as vibration isolators between air compressors and piping systems, and to allow connection of steam or compressed air atomizing media for oil burners on water tube boilers.

B. Units for Water Service:

1. Service: Refer to schematic diagrams for pressure, temperature and movement requirements. If requirements are not shown on the drawings, units shall be designed for maximum system pressure, temperature, axial movement and lateral movement.

2. Construction:

a. Teflon Bellows Type: Molded Teflon bellows with metal reinforcing rings, flanged ends, bolted limit rods.

b. Stainless Steel Bellows Type: Multi-ply stainless steel with flanged ends, bolted limit rods.

c. Flexible Metal Hose Type: Corrugated stainless steel hose wrapped with wire braid sheath. Ends shall be threaded, with union connectors, for pipe sizes 50 mm (2 inches) and below, flanged for pipe sizes 65 mm (2-1/2 inches) and greater.

C. Units for Compressed Air Service Only:

1. Service: Designed for 93 degrees C (200 degrees F), 1034 kPa (150 psig), and 15 mm (1/2 inch) intermittent offset.

2. Construction: Flexible corrugated stainless-steel hose wrapped with wire braid sheath. Provide threaded ends with union connectors.

D. Units for Atomizing Media Service (Steam, Compressed Air) and Steam Safety Valve Drip Pan Ell Drains:

1. Service: Designed for saturated steam at set pressure of boiler safety valves or for set pressure of compressor relief valve,

whichever is greater. Hose shall be designed for bend radii to suit location of connection points to burner piping system. Hose shall also be designed for intermittent flexing.

2. Construction: Flexible corrugated stainless-steel hose wrapped with wire braid sheath. Provide threaded ends with union connectors.

2.29 PIPING SUPPORT SYSTEMS

A. Provide an engineered piping support system with all hangers, supports and anchors designed and located by experienced technical pipe support specialists, utilizing piping system design and analysis software. The system design must be completely documented and submitted for review.

B. All pipe hangers and supports, and selection and installation shall comply with MSS SP-58 and MSS SP-127.

C. All pipe hanger and support devices must be in compliance with specified MSS SP-58 type numbers, have published load ratings, and be products of engineered pipe support manufacturers.

D. All pipe stresses and forces and moments on connecting equipment and structures shall be within the allowances of the ASME B31.1, applicable building codes, and equipment manufacturer’s design limits.

E. Piping that expands and contracts horizontally including steam, steam condensate, boiler feed, condensate transfer, shall be supported by roller or sliding type hangers and supports except when long vertical hanger rods permit sufficient horizontal movement with the vertical angles of the rods less than 4 degrees.

F. Piping that expands and contracts vertically including steam, steam condensate, boiler feed, condensate transfer, shall be supported by engineered variable spring and spring cushion hangers. Utilize MSS SP-58 selection requirements and guidelines. Vibration isolator hanger types are prohibited.

G. Seismic braces and shock absorbers shall be provided. Comply with MSS SP-127 design requirements and guidelines. Piping shall remain fully connected and supported under the design seismic events. Piping and connected equipment shall not be overstressed beyond code limits during seismic events.

H. Piping system anchors shall be engineered and located to control movement of piping that is subject to thermal expansion.

I. Prior to construction, submit complete engineering calculation methods and results, descriptions of all devices with MSS numbers, sizes, load capabilities and locations. Submit calculations on all moments and forces at anchors and guides, all hanger loads, all pipe stresses that are within 20 percent of the code allowable or exceed ASME B31.1 code allowable, all pipe movements at supports.

J. Detailed Design Requirements:

1. Piping system design and analysis software shall be current state of the art that performs ASME B31.1 code analyses and shall be utilized to analyze pipe movement and deflection, pipe stresses, pipe support forces and moments, and for selection of pipe support types and sizes. Seismic restraint calculations shall utilize the applicable shock spectra for the type of building structure, type of supported system, and the locality. Comply with MSS SP-127.
2. Each support for piping 65 mm (2-1/2 inches) and above shall be completely engineered to include location, type and size, hot and cold loads and movement. Submit layout drawings showing precise support locations and submit individual drawings for each support assembly showing all components, sizes, loadings.
3. Supports for piping 50 mm (2 inches) and below shall be engineered in general terms with approximate locations, typical support types and sizes, approximate movements. Submit layout drawings showing general locations and support types and sizes.
4. Obtain permissible loadings (forces and moments) for equipment nozzles (pipe connections) from the manufacturer of the boilers, the feedwater deaerator and any other equipment as necessary. Professional structural engineer shall verify capability of building structure to handle piping loads.
5. The project drawings may show locations and types of resilient supports including rollers and springs, and may also show special supports including anchors, guides and braces. Comply with the drawing requirements unless it is determined that piping may be overstressed or supports overloaded. Refer conflicts to the COR.
6. Variable spring hangers conforming the MSS SP-58, Type 51, shall support all piping that expands vertically from thermal effects which may include connected equipment, such as boilers. Spring rates

must be selected to avoid excessive load transfer to the connected equipment as the piping expands vertically. Vibration-type spring isolators are not acceptable. Light duty spring hangers, MSS SP-58, Type 48, may be utilized on loads of 91 kg (200 pounds) or less, and vertical movement of 3.2 mm (1/8 inches) or less. Spring cushion hangers, MSS SP-58, Type 49, may be utilized for vertical movement of 3.2 mm (1/8 inches) or less.

7. Locate supports to permit removal of valves and strainers from pipelines without disturbing supports.
8. If equipment and piping arrangement differs from that shown on the drawings, support locations and types shall be revised at no cost or time to the Government. The Government will also require a complete stress analysis of the system as-built at no additional cost or time to the Government.

K. Hangers and Supports - Products:
1. Factory-built products of a manufacturer specializing in engineered pipe supports. All components must have published load ratings. All spring type supports shall have published spring rates and movement limits. All support assemblies shall include threaded connections that permit vertical position adjustment. Supports shall comply with MSS SP-58 Type Numbers as listed below.
2. Upper Attachments to Building Structure: Types 18, 20, 21, 22, 23, 29, and 30.
3. Roller Supports: Types 41, 43, and 46. Provide vertical adjustment for Type 41 with threaded studs and nuts adjacent to the roller.
4. Variable Spring Hanger Assembly:
   a. Type 51 variable spring, with Type 3 pipe clamp or Type 1 clevis. Type 53 variable spring trapeze may also be used. Locate Type 51 variable spring within 300 mm (1 foot) above pipe attachment. Attach rod to top of variable spring with Type 14 clevis.
   b. Typical features of variable spring hangers include spring rates under 150 lb/in, enclosed spring, load and travel indicator, sizes available with load capabilities ranging from 50 lb to multiples of 10,000 lb.
5. Spring Cushion Hanger Assembly: Double Rod: Type 41 and 49.

6. Light Duty Spring Hanger Assembly: Type 48 light duty spring, with Type 3 pipe clamp or Type 1 clevis. Locate Type 48 light duty spring within 300 mm (1 foot) above pipe attachment.
7. Clevis Hangers: Type 1.
8. Wall Brackets: Type 31, 32, and 33.
9. Pipe Stands: Type 38.
10. Riser Clamps: Type 42.
11. Roller Guides: Type 44. Construct guides to restrain movement perpendicular to the long axis of the piping. All members shall be welded steel.
12. Trapeze Supports: May be used where pipes are close together and parallel. Construct with structural steel channels or angles. Bolt roller supports to steel to support piping subject to horizontal thermal expansion. Attach other piping with U-bolts.
13. Pipe Covering Protection Saddles: Type 39. Provide at all support points on insulated pipe except where Type 3 pipe clamp is provided. Insulation shields are prohibited. Refer to Section 23 07 11, HVAC AND BOILER PLANT INSULATION.
14. Sliding Supports: Type 35. Welded steel attachments to pipe and building structure with Teflon or graphite sliding surfaces bonded to the attachments. Provide steel guides, except at expansion bends, to prevent lateral movement of the pipe.
15. Piping Anchors: Provide engineered designs to accommodate the calculated loads. All ferrous material shall be painted in accordance with Section 09 91 00, PAINTING.
16. Seismic Restraints:
    a. Comply with MSS SP-127.
    b. Bracing: Provide as determined by engineering calculations.
    c. Shock Absorbers: Type 50. Mechanical or hydraulic type rated for shock loads. Pipe attachments shall be Type 3.

2.30 PIPE AND VALVE FLANGE GASKETS

A. Non-asbestos, designed for the service conditions. On steam service utilize 3.2 mm (1/8 inch) thick Class 300 spiral-wound with Type 304 stainless steel and mica/graphite filler and carbon steel gauge ring.

2.31 THREAD SEALANTS

A. As recommended by the sealant manufacturer for the service. Teflon tape of any type is prohibited on fuel oil systems.

2.32 PIPE SLEEVES

A. Service: For pipes passing through floors, walls, partitions.

B. Construction: Steel pipe, schedule 10 minimum.

C. Sleeve Diameter: Not less than 25 mm (1 inch) larger than the diameter of the enclosed pipe and thermal insulation, vapor barrier, and protective covering for insulated pipe; sleeves for un-insulated pipe shall be not less than 25 mm (1 inch) larger than the diameter of the enclosed pipe.

PART 3 - EXECUTION

3.1 GENERAL

A. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no additional cost or time to the Government.

3.2 ARRANGEMENT OF PIPING

A. The piping arrangement shown is a design based on currently available equipment. The plans show typical equipment to scale and show practical arrangement. Modification will be necessary during construction, at no additional cost or time to the Government, to adapt the equipment layout and piping plans to the precise equipment purchased by the Contractor. Accessibility for operation and maintenance must be maintained.

B. All piping shall be installed parallel to walls and column centerlines (unless shown otherwise). Fully coordinate work of each trade to provide the designed systems without interference between systems. All piping shall be accurately cut, true, and beveled for welding. Threaded piping shall be accurately cut, reamed and threaded with sharp dies. Copper piping work shall be performed in accordance with best practices requiring accurately cut clean joints and soldering in accordance with the recommended practices for the material and solder employed. Compression type fittings are prohibited.

C. All piping shall be pitched for drainage at a constant slope of 25 mm in 12 m (1 inch in 40 feet). Steam, condensate, trap discharge, drip, drain, air, gas and blowdown piping shall pitch down in direction of flow. Service water, pumped condensate, pumped boiler feedwater, oil, shall pitch up in direction of flow. Provide valved air vents at top of rise and valved drains at low points. Gas piping may be run level as it is presumed to be dry, but dirt pockets shall be provided at base of risers.

D. Valves shall be located, and stems oriented to permit proper and easy operation and access to valve bonnet for maintenance of packing, seat and disc. Valve stems shall not be below centerline of pipe. Refer to plans for stem orientation. Where valves are more than 2.1 m (7 feet) above the floor or platform, stems shall be horizontal unless shown otherwise. Gate and globe valves more than 3 m (10 feet) above floor or platform, shall be accessed using additional permanent work platforms to be provided by contractor. Provide hammer-blow wheel on any valve that cannot be opened or tightly closed by one person. Steam line gate and butterfly type isolation valves 75 mm (3 inch) pipe size and above shall have factory or field-fabricated 20 mm or 25 mm (3/4 inch or 1 inch) globe-valved warm-up bypasses if the steam line length is 6.1 m (20 feet) or longer.

E. Provide union adjacent to all threaded end valves.

F. Bolt wafer-type butterfly valves between pipe flanges.

G. Provide valves as necessary to permit maintenance of a device or sub-system without discontinuing service to other elements of that service or system.

H. Do not install any piping within 600 mm (2 feet) of water tube boiler side or top casings.

3.3 WELDING

A. The contractor is entirely responsible for the quality of the welding and shall:

1. Conduct tests of the welding procedures used on the project, verify the suitability of the procedures used, verify that the welds made will meet the required tests, and also verify that the welding operators have the ability to make sound welds under standard conditions.
2. Perform all welding operations required for construction and installation of the piping systems.

B. Qualification of Welders: Rules of procedure for qualification of all welders and general requirements for fusion welding shall conform with the applicable portions of ASME B31.1, AWS B2.1/B2.1M, AWS Z49.1, and also as outlined below.

C. Examining Welder: Examine each welder at job site, in the presence of the COR, to determine the ability of the welder to meet the qualifications required. Test welders for piping for all positions, including welds with the axis horizontal (not rolled) and with the axis vertical. Each welder shall be allowed to weld only in the position in which he has qualified and shall be required to identify his welds with his specific code marking signifying his name and number assigned.

D. Examination Results: Provide the COR with a list of names and corresponding code markings. Retest welders who fail to meet the prescribed welding qualifications. Disqualify welders, who fail the second test, for work on the project.

E. Beveling: Field bevels and shop bevels shall be done by mechanical means or by flame cutting. Where beveling is done by flame cutting, surfaces shall be thoroughly cleaned of scale and oxidation just prior to welding. Conform to specified standards.

F. Alignment: Provide approved welding method for joints on all pipes greater than 50 mm (2 inches) to assure proper alignment, complete weld penetration, and prevention of weld spatter reaching the interior of the pipe.

G. Erection: Piping shall not be split, bent, flattened, or otherwise damaged before, during, or after installation. If the pipe temperature falls to 0 degrees C (32 degrees F) or lower, the pipe shall be heated to approximately 38 degrees C (100 degrees F) for a distance of 300 mm (1 foot) on each side of the weld before welding, and the weld shall be finished before the pipe cools to 0 degrees C (32 degrees F).

H. Non-Destructive Examination of Piping Welds:

1. Perform radiographic examination of 50 percent of the first 10 welds made and 10 percent of all additional welds made. The COR reserves the right to identify individual welds for which the radiographic examination must be performed. All welds will be visually inspected by the COR. The VA reserves the right to require testing on

additional welds up to 100 percent if more than 25 percent of the examined welds fail the inspection.

2. An approved independent testing firm regularly engaged in radiographic testing shall perform the radiographic examination of pipe joint welds. All radiographs shall be reviewed and interpreted by an ASNT Certified Level III radiographer, employed by the testing firm, who shall sign the reading report.
3. Comply with ASME B31.1. Furnish a set of films showing each weld inspected, a reading report evaluating the quality of each weld, and a location plan showing the physical location where each weld is to be found in the completed project. The COR and the commissioning agent shall be given a copy of all reports to be maintained as part of the project records and shall review all inspection records.

I. Defective Welds: Replace and reinspect defective welds. Repairing defective welds by adding weld material over the defect or by peening are prohibited. Welders responsible for defective welds must be requalified prior to resuming work on the project.

J. Electrodes: Electrodes shall be stored in a dry heated area and be kept free of moisture and dampness during the fabrication operations. Discard electrodes that have lost part of their coating.

3.4 PIPING JOINTS

A. All butt-welded piping shall be welded at circumferential joints, flanges shall be weld neck type; slip-on flanges, screwed flanges may be applied only with written approval of the COR.

B. Companion flanges at equipment or valves shall match flange construction of equipment or valve. Raised face shall be removed at all companion flanges when attached to flanges equipped for flat face construction.

C. Gaskets and bolting shall be applied in accordance with the recommendations of the gasket manufacturer and bolting standards of ASME B31.1. Strains shall be evenly applied without overstress of bolts. Gaskets shall cover entire area of mating faces of flanges.

D. Screw threads shall be made up with Teflon tape except gas and oil piping joints shall utilize specified joint compound.

E. Solder joints shall be made up in accordance with recommended practices of the materials applied. Apply 95/5 tin and antimony on all copper piping. The COR or their representative reserves the right to reject any soldered joints based on the appearance of excessive heat, solder build up or not evenly distributed around the joint, or excessive flux build up. In which case, the contractor shall remove, clean, and replace joints at no additional cost or time to the Government.

3.5 BRANCH INTERSECTION CONNECTIONS

A. Factory-built reinforced tees and laterals are required.

B. Factory-built integrally-reinforced forged steel branch outlet fittings may be used on reduced size connections upon approval of COR. They must comply with MSS SP-97.

3.6 EXPANSION AND FLEXIBILITY

A. The design includes provision for piping expansion due to pressure, thermal, weight and seismic (where applicable) effects. It is the Contractor's responsibility to avoid reduction in flexibility and increase in stress in piping systems. Major deviation will be shown by submittal for review of scale working drawings and stress calculations for the piping systems. Contractor shall provide any necessary additional construction and materials to limit stresses to safe values as directed by the COR and at no additional cost or time to the Government.

3.7 PIPE BENDING

A. Pipe bending shall be in accordance with the recommended practices of PFI ES24. Only ASTM A106/A106M seamless pipe may be bent. Sizes below 50 mm (2 inches) may be bent in field; sizes 65 mm (2-1/2 inches) and larger shall have factory-fabricated bends. Minimum radii and tangent lengths for field bent piping are shown in the following table:

Size	Minimum Radius	Minimum Tangent
15 mm (1/2 inch)	65 mm (2-1/2 inches)	40 mm (1-1/2 inches)
20 mm (3/4 inch)	70 mm (2-3/4 inches)	45 mm (1-3/4 inches)
25 mm (1 inch)	125 mm (5 inches)	50 mm (2 inches)
32 mm (1-1/4 inches)	159 mm (6-1/4 inches)	50 mm (2 inches)
40 mm (1-1/2 inches)	191 mm (7-1/2 inches)	65 mm (2-1/2 inches)

3.8 SIZE CHANGES

A. Piping size changes shall be accomplished by use of line reducers, reducing ell, reducing tee. Apply eccentric reduction in all piping requiring continuous drainage; steam, condensate, vacuum, blowdown. Concentric reduction may be applied in run of piping involving pressure water systems except at pump inlets. Use concentric increasers where flow is in direction of increased size. Eccentric reduction, top flat, at all pump connections.

3.9 ADDITIONAL DRIPS AND TRAPS

A. Where additional rises or drops in steam or gas lines are provided, provide additional drip pockets with steam trap assemblies on steam lines and additional dirt pockets on gas lines. All air drops shall have dirt legs and no actuator or other air operated equipment may come off the end of the air line. Airline taps are either from the top of the supplying line if the supply line is horizontal or from the side if the supplying line is vertical. All air operated equipment shall have inline moisture separators or dryers.

3.10 MINOR PIPING

A. Minor piping associated with instrumentation and control is generally not shown. Interconnection of sensors, transducers, control devices, instrumentation panels, combustion control panel, burner control panels is the responsibility of the contractor. Small piping associated with water cooling, drips, drains and other minor piping may not be shown to avoid confusion in the plan presentation but shall be provided as part of contract work.

3.11 DIELECTRIC CONNECTION

A. Where copper piping is connected to steel piping provide dielectric connections.

3.12 INSTALLATION - BOILER EXTERNAL STEAM PIPING FROM BOILER TO MAIN HEADER

A. From Boiler to Second Stop Valve: Fabricate from boiler nozzle through second stop valve under the rules for boiler external piping of the ASME BPVC Section I. Full compliance will be required, including qualification of welders, Code inspection, and certification with ASME Form P4A. Deliver original of Form P4A properly executed to COR.

B. Construction shall include: non-return stop and check valve at the boiler, welding coupling for 20 mm (3/4 inch) vent, second stop valve, steam flowmeter primary element, welding coupling for IPT calorimeter connection located to provide clear space and access for temporary test calorimeter, and header stop valve. Second stop valve may be deleted if the entire steam line from the non-return valve to the header valve is constructed in accordance with the rules for boiler external piping, ASME BPVC Section I.

C. Companion flange at 2070 kPa (300 psig) valves shall be 2070 kPa (300 psig) weld neck; at 1034 kPa (150 psig) valves shall be 1034 kPa (150 psig) weld neck.

D. Equip header stop valve with factory applied warm-up bypass connected to drilled and tapped bosses in valve body located above and below valve wedge. Connect valved drain to header valve body boss located above valve wedge.

E. Equip steam pipe with 20 mm (3/4 inch) vent, 1380 kPa (200 psig) steel gate valve, as specified.

F. Support and slope boiler steam line to drain; apply variable spring hangers (MSS-SP58, Type 51 or 53).

G. Provide screwed fitting for calorimeter (temporary test instrument) on side of pipe as shown. Allow 600 mm (2 feet) horizontal and vertical clearance for calorimeter.

H. Handwheel and drain valve on non-return stop check valve shall be within easy reach of boiler platform.

I. Disassemble, clean and reassemble entire mechanism of non-return stop check valve after conclusion of boiler testing.

3.13 INSTALLATION - MAIN STEAM HEADER

A. The header shall be the connection point for steam piping from all boilers and for steam distribution piping. The boiler plant steam pressure control transmitter shall be connected to the header.

B. Steam header shall be assembly of tees, pipe sections, and weld neck flanges.

C. Factory-fabricated forged steel integrally reinforced branch outlet welding fittings, standard weight, ASTM A105/A105M Grade 2, may be applied in lieu of tees for all branch outlets less than the full size of the header. Comply with fitting manufacturer's recommendations and requirements of ASME B31.1 and MSS SP-97.

D. Provide header supports and anchor as shown; apply insulation saddles for insulation thickness as required in Section 23 07 11, HVAC AND BOILER PLANT INSULATION.

E. Weld neck flange bolt position shall conform to required valve, stem, and bypass orientation as shown.

F. Header construction as specified includes the entire header and branches to first valve.

G. Anchor and guide header to resist thermal and weight forces and also seismic forces where required.

H. All valves must be accessible without the use of ladders or chain-wheels.

3.14 INSTALLATION - BOILER BOTTOM BLOWOFF PIPING

A. Fabricate with long swiping radius ells, Y-form laterals. Tees and crosses are prohibited.

3.15 INSTALLATION - EXHAUST HEAD MOUNTED ABOVE ROOF

A. Provide drain line from connection on exhaust head to roof drain. Provide pipe size same as drain connection size.

3.16 INSTALLATION – SIGHT FLOW INDICATORS

A. Locate to permit view from floor or platform.

3.17 INSTALLATION - PRESSURE AND TEMPERATURE REGULATORS, CONTROL VALVES, SAFETY SHUT-OFF VALVES

A. Provide sufficient clearance on all sides of valve to permit replacement of working parts without removing valve from pipeline.

B. Maintain access.

3.18 INSTALLATION - EMERGENCY GAS SAFETY SHUT-OFF VALVES AND EARTHQUAKE VALVES

A. Locate so that valve position indicator is visible from nearest walkway.

B. Provide control wiring and wiring to annunciator on instrumentation panel and to computer workstation (if provided).

C. Maintain access to the valve so that it can be easily maintained or reset.

3.19 INSTALLATION - FLEXIBLE CONNECTORS

A. Install units for water and compressed air service in a straight run of pipe. Units for atomizing media service may be installed with bends if necessary. Designer of atomizing media piping must coordinate hose connection points with allowable bend radius of hose.

3.20 INSTALLATION - SAFETY VALVES, RELIEF VALVES AND SAFETY-RELIEF VALVES

A. Orient valves so that lifting levers are accessible from nearest walkway or access platform. Valves must be removable without requiring disassembling of vents, except where otherwise specifically provided.

B. Provide a drip pan elbow at discharge of each steam or economizer valve with slip joint in vent discharge line, arranged to prevent vent line from imposing any force on valve and to prevent any moisture accumulation in valve. Connected drip pan ell drains to drain piping to floor drain. Provide flexible connector on drain line, adjacent to drip pan ell.

C. Support vent line from above. Each steam valve must have separate vent line to atmosphere unless shown otherwise.

1. Vent lines shall have no more than a total of 180 degrees of directional changes and any one change is limited to 45 degrees to limit back pressure. The COR may reject any vent based on back pressure and blow by during testing.
2. Use stainless steel Schedule 40 piping for horizontal sections of vent piping. Use dielectric unions or flange gaskets at each dissimilar material vent joint.

D. Relief valves in steam piping shall have a manual valve downstream of the relief valve to allow for testing of the valve in place without risk of over pressurizing downstream equipment.

3.21 INSTALLATION – Y-TYPE STRAINERS ON STEAM SERVICE

A. Install with basket level with the steam pipe so that condensate is not trapped in the strainer.

3.22 INSTALLATION - QUICK COUPLE HOSE CONNECTORS

A. Install male plugs on each piping drain. Connect socket to one end of steam hose.

3.23 INSTALLATION - VIBRATION ISOLATORS IN PIPING

A. Install on all air lines and water supply lines to air compressors.

B. Also install on pump connections as shown.

3.24 INSTALLATION - PIPE SLEEVES

A. Accurately locate and securely fasten sleeves to forms before concrete is poured; install in walls or partitions during the construction of the walls.

B. Sleeve ends shall be flush with finished faces of walls and partitions.

C. Pipe sleeves passing through floors shall project 25 mm (1 inch) minimum above the finished floor surface and the bottom of the sleeve shall be flush with the underside of the floor slab.

3.25 INSTALLATION – PIPE SUPPORT SYSTEMS

A. Coordinate support locations with building structure prior to erection of piping. Also refer to approved shop drawings of equipment and approved piping layout and hanger layout drawings when locating hangers. Arrangement of supports shall facilitate operating, servicing and removal of valves, strainers, and piping specialties. Hanger parts must be marked at the factory with a numbering system keyed to hanger layout drawings. Layout drawings must be available at the site.

B. Upper attachments to Building Structure:

1. New Reinforced Concrete Construction: Concrete inserts.
2. Existing Reinforced Concrete Construction: Upper attachment welded or clamped to steel clip angles (or other construction shown on the drawings) which are expansion-bolted to the concrete. Expansion bolting shall be located so that loads place bolts in shear.
3. Steel Deck and Structural Framing: Upper attachments welded or clamped to structural steel members.

C. Expansion Fasteners and Power Set Fasteners: In existing concrete floor, ceiling and wall construction, expansion fasteners may be used for hanger loads up to 1/3 the manufacturer's rated strength of the expansion fastener. Power set fasteners may be used for loads up to 1/4 of rated load. When greater hanger loads are encountered, additional fasteners may be used and interconnected with steel members combining to support the hanger.

D. Special Supports:

1. Secure horizontal pipes where necessary to prevent vibration or excess sway.
2. Where hangers cannot be adequately secured as specified, (for example, support for flow metering sensing lines, control piping) special provisions shall be made for hanging and supporting pipe as directed by the COR.
3. Pipe supports, hangers, clamps or anchors shall not be attached to equipment unless specifically permitted by the specifications for

that equipment or unless COR gives written permission. Attachments to boiler casings are prohibited.

E. Spring Hangers: Locate spring units within one foot of the pipe, breeching or stack attachment except in locations where spring assemblies interfere with pipe insulation. Adjust springs to loads calculated by hanger manufacturer.

F. Seismic Braces and Restraints: Provide is accordance with Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS. Do not insulate piping within one foot of device until device has been inspected by COR.

3.26 CLEANING OF PIPING AFTER INSTALLATION

A. Flush all piping sufficiently to remove all dirt and debris. Fill piping completely. Velocity shall be equivalent to that experienced during normal plant operation at maximum loads. During flushing, all control valves, steam traps and pumps must be disconnected from the system. After cleaning is complete, remove, clean and replace all strainer baskets and elements. Reconnect all equipment. Provide safe points of discharge for debris blown from pipes. Flushing of the systems shall be witnessed by the COR or their representative. Provide documentation of system flow rates to flushing flow rates and for how long was the flow maintained.

3.27 TESTING

A. Testing of piping components is not required prior to installation. Valves and fittings shall be capable of withstanding hydrostatic shell test equal to twice the primary design service pressure except as modified by specifications on fittings, ASME B16.5. This test capability is a statement of quality of material. Tests of individual items of pipe, fittings or equipment will be required only on instruction of COR and at Government cost, except where required by the specifications for specific equipment such as the boilers.

B. After erection, all piping systems shall be capable of withstanding a hydrostatic test pressure of 1.5 times design pressure, as stipulated in ASME B31.1. Hydrostatic tests will be required only on boiler external steam piping, utilizing water as the test medium. Hydrostatic tests will be required on other piping when operating tests described are unsatisfactory, or when inspection of welds shows poor workmanship and is subject to question by the COR. When hydrostatic tests show leaks, the COR will require necessary welding repairs, in accordance with ASME B31.1, at the Contractor's cost.

C. Perform operating test as follows:
   1. All steam piping prior to insulation shall be subjected to steam at final operating pressure. Inspect all joints for leaks and workmanship. Corrections shall be made as specified. If insulation is installed prior to these tests the contractor shall be required to remove and reinstall insulation after the test has been completed at no additional cost or time to the Government.
   2. Test main gas piping and LP gas piping at 2 times their respective design pressure up to a maximum of 103 kPa (15 psig), with compressed air for 2 hours with pressure source disconnected and with decay in pressure not to exceed 5 percent. Corrections to the readings are permissible to compensate for significant ambient temperature changes during the test period. Test joints with soap solution, check thoroughly for leaks.
   3. Test boiler feedwater, condensate, vacuum and service water systems under service conditions and prove tight.
   4. Test oil and compressed air systems under service conditions at pressure equal to highest setting of safety and relief valves in the individual systems.
   5. Make corrections and retests to establish systems that have no leaks. Replace or recut any defective fittings or defective threads. Soldered material shall be thoroughly cleaned prior to resoldering. Back welding of threads is prohibited.

D. Hydrostatically test boiler external steam piping from boiler to header in approved manner with water at same time boiler is hydrostatically tested under the supervision of COR. Prior to hydrostatic test, remove all valves not rated for hydrostatic test pressure. Replace valves after tests are satisfactorily completed. Hydrostatic test pressure shall be 1.5 times design pressure and performed in accordance with ASME BPVC Section I.

E. Prepare and submit test and inspection reports to the COR within 5 working days of test completion and prior to covering the pipe.

F. All tests shall be witnessed by the COR, their representative, or the commissioning agent and be documented by each section tested, date tested, and list or personnel present.

G. Generally, insulation work should not be performed prior to testing of piping. Contractor may, at own option and hazard, insulate piping prior to test, but any damaged insulation shall be replaced with new quality as specified for original installation at Contractor's cost and time.

H. Safety, Safety-Relief, Relief Valves: After installation, test under pressure in presence of COR. Test operation, including set pressure, flow, and blowdown in accordance with ASME BPVC. Install relief valve set at pressure no more than 1/3 higher than test pressure and replace safety valves of the appropriate pressure. Reset pressure setpoint of all relief valves to the appropriate pressures and replace safety valves after all tests have been completed. Contractor to provide written report of the reset with date and time stamp for each relief valve and replacement of the safety valves. Any deficiencies must be corrected, and retest performed. Refer to Section 23 52 39, FIRE-TUBE BOILERS for boiler safety valve test requirements.

3.28 STARTUP AND TESTING

A. Perform tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.

B. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.

C. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with COR and Commissioning Agent. Provide a minimum notice of 10 working days prior to startup and testing.

3.29 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

B. Components provided under this section of the specification will be tested as part of a larger system.

3.30 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer's technical representative for 4 hours to instruct each VA personnel responsible in operation and maintenance of the system.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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SECTION 23 21 13
HYDRONIC PIPING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Water piping to connect HVAC equipment, including the following:

1. Chilled water, condenser water, heating hot water and drain piping.
2. Extension of domestic water make-up piping for HVAC systems.
3. Glycol-water piping.

B. A complete listing of common acronyms and abbreviations are included in Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

C. Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.

D. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

E. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS: Seismic restraints for piping.

F. Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION.

G. 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.

H. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.

I. Section 23 07 11, HVAC AND BOILER PLANT INSULATION: Piping insulation.

J. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

K. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC: Temperature and pressure sensors and valve operators.

L. Section 23 22 13, STEAM AND CONDENSATE HEATING PIPING.

M. Section 23 25 00, HVAC WATER TREATMENT: Water treatment for open and closed systems.

N. Section 31 20 00, EARTHWORK: Excavation and backfill.

1.3 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Where conflicts occur these specifications and the VHA standard will govern.

B. American Society of Mechanical Engineers (ASME):

B1.20.1-2013...........Pipe Threads, General Purpose (Inch)

B16.3-2016.............Malleable Iron Threaded Fittings: Classes 150 and 300

B16.4-2016.............Gray Iron Threaded Fittings: (Classes 125 and 250)

B16.5-2017.............Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard

B16.9-2018.............Factory Made Wrought Buttwelding Fittings

B16.11-2016............Forged Fittings, Socket-Welding and Threaded

B16.18-2018............Cast Copper Alloy Solder Joint Pressure Fittings

B16.22-2018............Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings

B16.24-2016............Cast Copper Alloy Pipe Flanges and Flanged Fittings: Classes 150, 300, 600, 900, 1500, and 2500

B16.39-2014............Malleable Iron Threaded Pipe Unions: Classes 150, 250, and 300

B16.42-2016............Ductile Iron Pipe Flanges and Flanged Fittings

B31.9-2014.............Building Services Piping

B40.100-2013...........Pressure Gauges and Gauge Attachments

ASME Boiler and Pressure Vessel Code:

BPVC Section VIII-2015..Rules for Construction of Pressure Vessels

C. American Society for Testing and Materials (ASTM):

A47/A47M-2018..........Standard Specification for Ferritic Malleable Iron Castings

A53/A53M-2018..........Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

A106/A106M-2019.........Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service

A126-2004(R2019)........Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings

A183-2014...............Standard Specification for Carbon Steel Track Bolts and Nuts

A216/A216M-2018.........Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service

A307-2016...............Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 PSI Tensile Strength

A536-1984(R2019)........Standard Specification for Ductile Iron Castings

B62-2017................Standard Specification for Composition Bronze or Ounce Metal Castings

B88-2016................Standard Specification for Seamless Copper Water Tube

F439-2019...............Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80

F441/F441M-2015.........Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80

D. American Welding Society (AWS):

B2.1/B2.1M-2014.........Standard for Welding Procedure and Performance Specification

E. Expansion Joint Manufacturer’s Association, Inc. (EJMA):

EJMA 2017...............Expansion Joint Manufacturer’s Association Standards, Tenth Edition

F. Manufacturers Standardization Society (MSS) of the Valve and Fitting Industry, Inc.:

SP-67-2017..............Butterfly Valves

SP-70-2014..............Gray Iron Gate Valves, Flanged and Threaded Ends

SP-71-2014..............Gray Iron Swing Check Valves, Flanged and Threaded Ends

SP-80-2014..............Bronze Gate, Globe, Angle, and Check Valves

SP-85-2014..............Gray Iron Globe and Angle Valves, Flanged and Threaded Ends

SP-110-2014.............Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends

SP-125-2018.............Gray Iron and Ductile Iron In-line, Spring-Loaded, Center-Guided Check Valves

G. Tubular Exchanger Manufacturers Association (TEMA):

TEMA Standards2015......9th Edition

1.4 SUBMITTALS

A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Information and material submitted under this section shall be marked “SUBMITTED UNDER SECTION 23 21 13, HYDRONIC PIPING”, with applicable paragraph identification.

C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.

1. Pipe and equipment supports. Submit calculations for variable spring and constant support hangers.
2. Pipe and tubing, with specification, class or type, and schedule.
3. Pipe fittings, including miscellaneous adapters and special fittings.
4. Flanges, gaskets and bolting.
5. Couplings and fittings.
6. Valves of all types.
7. Strainers.
8. Flexible connectors for water service.
9. Pipe alignment guides.
10. Expansion joints.
11. Expansion compensators.
12. All specified hydronic system components.

13. Water flow measuring devices.
14. Gauges.
15. Thermometers and test wells.
16. Electric heat tracing systems.
17. Seismic bracing details for piping.

D. Manufacturer's certified data report, Form No. U-1, for ASME pressure vessels:

E. Submit the welder’s qualifications in the form of a current (less than one-year old) and formal certificate.

F. Coordination Drawings: Refer to paragraph, SUBMITTALS of Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

G. As-Built Piping Diagrams: Provide drawing as follows for chilled water, condenser 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.

H. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replacement parts, and troubleshooting guide:
   1. Include complete list indicating all components of the systems.
   2. Include complete diagrams of the internal wiring for each item of equipment.
   3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

I. Completed System Readiness Checklist provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

J. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

1.5 QUALITY ASSURANCE

A. Section 23 05 11, COMMON WORK RESULTS FOR HVAC, which includes welding qualifications.

B. Submit prior to welding of steel piping a certificate of Welder's certification. The certificate shall be current and not more than one-year old.

C. All couplings, fittings, valves, and specialties shall be the products of a single manufacturer.
   1. All castings used for coupling housings, fittings, valve bodies, etc., shall be date stamped for quality assurance and traceability.

1.6 AS-BUILT DOCUMENTATION

A. Submit manufacturer's literature and data updated to include submittal review comments and any equipment substitutions.

B. Submit operation and maintenance data updated to include submittal review comments, VA approved substitutions and construction revisions shall be in electronic version on CD or DVD inserted into a three-ring binder. All aspects of system operation and maintenance procedures, including applicable piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices shall be included. A List of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.

C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the 'third party testing company' requirement. Provide record drawings as follows:
   1. As-built drawings are to be provided, with a copy of them on AutoCAD provided on CD or DVD. The CAD drawings shall use multiple line layers with a separate individual layer for each system.

D. The as-built drawings shall indicate the location and type of all lockout/tagout points for all energy sources for all equipment and

pumps to include breaker location and numbers, valve tag numbers, etc. Coordinate lockout/tagout procedures and practices with local VA requirements.

E. Certification documentation shall be provided to COR 21 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and provide documentation/certification that all results of tests were within limits specified. Test results shall contain written sequence of test procedure with written test results annotated at each step along with the expected outcome or setpoint. The results shall include all readings, including but not limited to data on device (make, model and performance characteristics), normal pressures, switch ranges, trip points, amp readings, and calibration data to include equipment serial numbers or individual identifications, etc.

1.7 SPARE PARTS

A. For mechanical pressed sealed fittings provide tools required for each pipe size used at the facility.

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. Extension of Domestic Water Make-up Piping: ASTM B88, Type K or L, hard drawn copper tubing.

B. Cooling Coil Condensate Drain Piping:

1. From air handling units: Copper water tube, ASTM B88, Type M, or Schedule 40 PVC plastic piping.
2. From fan coil or other terminal units: Copper water tube, ASTM B88, Type M for runouts and Type L for mains.

C. Pipe supports, including insulation shields, for 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.
   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 3.2 mm (1/8 inch) thick full-face neoprene gasket suitable for 104 degrees C (220 degrees F).
         1) Contractor's option: Convoluted, cold formed 150-pound steel flanges, with Teflon gaskets, may be used for water service.
      b. Flange bolting: Carbon steel machine bolts or studs and nuts, ASTM A307, Grade B.

C. Welded Branch and Tap Connections: Forged steel weldolets, or branchlets and threadolets may be used for branch connections up to one pipe size smaller than the main. Forged steel half-couplings, ASME B16.11 may be used for drain, vent and gauge connections.

2.4 FITTINGS FOR COPPER TUBING

A. Joints:
   1. Solder Joints: Joints shall be made up in accordance with recommended practices of the materials applied. Apply 95/5 tin and antimony on all copper piping.
   2. Mechanically formed tee connection in water and drain piping: Form mechanically extracted collars in a continuous operation by drilling pilot hole and drawing out tube surface to form collar, having a height of not less than three times the thickness of tube wall.

Adjustable collaring device shall ensure proper tolerance and complete uniformity of the joint. Notch and dimple joining branch tube in a single process to provide free flow where the branch tube penetrates the fitting.

B. Bronze Flanges and Flanged Fittings: ASME B16.24.

C. Fittings: ASME B16.18 cast copper or ASME B16.22 solder wrought copper.

2.5 FITTINGS FOR PLASTIC PIPING

A. Schedule 40, socket type for solvent welding.

B. Schedule 40 PVC drain piping: Drainage pattern.

C. Chemical feed piping for condenser water treatment: CPVC, Schedule 80, ASTM F439.

2.6 DIELECTRIC FITTINGS

A. Provide where copper tubing and ferrous metal pipe are joined.

B. 50 mm (2 inches) and Smaller: Threaded dielectric union, ASME B16.39.

C. 65 mm (2-1/2 inches) and Larger: Flange union with dielectric gasket and bolt sleeves, ASME B16.42. Dielectric gasket material shall be compatible with hydronic medium.

D. Temperature Rating, 99 degrees C (210 degrees F).

E. Contractor’s option: On pipe sizes 50 mm (2 inch) and smaller, screwed end brass ball valves may be used in lieu of dielectric unions.

2.7 SCREWED JOINTS

A. Pipe Thread: ASME B1.20.1.

B. Lubricant or Sealant: Oil and graphite or other compound approved for the intended service.

2.8 VALVES

A. Asbestos packing is not acceptable.

B. All valves of the same type shall be products of a single manufacturer.

C. Provide chain operators for valves 150 mm (6 inches) and larger when the centerline is located 2.4 m (8 feet) or more above the floor or operating platform.

D. Shut-Off Valves:

1. Ball Valves (Pipe sizes 50 mm (2 inch) and smaller): MSS SP-110, screwed or solder connections, brass or bronze body with chrome-plated ball with full port and Teflon seat at 2758 kPa (400 psig) working pressure rating. Provide stem extension to allow operation without interfering with pipe insulation.

2. Butterfly Valves (Pipe Sizes 65 mm (2-1/2 inch) and larger): Provide stem extension to allow 50 mm (2 inches) of pipe insulation without interfering with valve operation. MSS SP-67, flange lug type rated 1200 kPa (175 psig) working pressure at 93 degrees C (200 degrees F). Valves shall be ANSI Leakage Class VI and rated for bubble tight shut-off to full valve pressure rating. Valve shall be rated for dead end service and bi-directional flow capability to full rated pressure. Butterfly valves are prohibited for direct buried pipe applications.
   a. Body: Cast iron, ASTM A126, Class B. Malleable iron, ASTM A47/A47M electro-plated, or ductile iron, ASTM A536, Grade 65-45-12 electro-plated.
   b. Trim: Bronze, aluminum bronze, or 300 series stainless steel disc, bronze bearings, 316 stainless steel shaft and manufacturer's recommended resilient seat. Resilient seat shall be field replaceable, and fully line the body to completely isolate the body from the product. A phosphate coated steel shaft or stem is acceptable, if the stem is completely isolated from the product.
   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 handwheel, and where required, chain-wheel operator.
      3) Gate Valves:
         a) 50 mm (2 inches) and smaller: MSS SP-80, Bronze, 1035 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, 1035 kPa (150 psig) 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:
      a. 50 mm (2 inches) and smaller: MSS SP-80, bronze, 1035 kPa (150 psig) 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, 1035 kPa (150 psig), 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/A216M, Class WCB, or ductile iron, ASTM 536, flanged or wafer type.
      b. Seat, disc and spring: 18-8 stainless steel, or bronze, ASTM B62. Seats may be elastomer material.
G. Water Flow Balancing Valves: For flow regulation and shut-off. Valves shall be line size rather than reduced to control valve size.
   1. Globe style valve.
   2. A dual-purpose flow balancing valve and adjustable flow meter, with bronze or cast-iron body, calibrated position pointer, valved pressure taps or quick disconnects with integral check valves and preformed polyurethane insulating enclosure.

3. 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 27 to 393 kPa (4 to 57 psig). Provide standard pressure taps and four sets of capacity charts. Valves shall be line size and be one of the following designs:
   1. Gray iron ASTM A126 or brass body rated 1200 kPa (175 psig) at 93 degrees C (200 degrees F), with stainless steel piston and spring.
   2. Brass or ferrous body designed for 2070 kPa (300 psig) service at 121 degrees C (250 degrees F), with corrosion resistant, tamper proof, self-cleaning piston/spring assembly that is easily removable for inspection or replacement.
   3. Combination assemblies containing ball type shut-off valves, unions, flow regulators, strainers with blowdown valves and pressure temperature ports shall be acceptable.

   4. Provide a readout kit including flow meter, probes, hoses, flow charts and carrying case.

I. Manual Radiator/Convector Valves: Brass, packless, with position indicator.

2.9 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. Wafer Type Circuit Sensor: Cast iron wafer-type flow meter equipped with readout valves to facilitate the connecting of a differential pressure meter. Each readout valve shall be fitted with an integral check valve designed to minimize system fluid loss during the monitoring process.

D. Self-Averaging Annular Sensor Type: Brass or stainless-steel metering tube, shutoff valves and quick-coupling pressure connections. Metering tube shall be rotatable so all sensing ports may be pointed down-stream when unit is not in use.

E. Insertion Turbine Type Sensor: Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

F. Flow Measuring Device Identification:

1. Metal tag attached by chain to the device.
2. Include meter or equipment number, manufacturer's name, meter model, flow rate factor and design flow rate in gpm.

G. Portable Water Flow Indicating Meters:

1. Minimum 150 mm (6 inch) diameter dial, forged brass body, beryllium-copper bellows, designed for 1200 kPa (175 psig) working pressure at 121 degrees C (250 degrees F).
2. Bleed and equalizing valves.
3. Vent and drain hose and two 3 m (10 feet) lengths of hose with quick disconnect connections.
4. Factory-fabricated carrying case with hose compartment and a bound set of capacity curves showing flow rate versus pressure differential.
5. Provide one portable meter for each range of differential pressure required for the installed flow devices.

H. Permanently Mounted Water Flow Indicating Meters: Minimum 150 mm (6 inch) diameter, or 457 mm (18 inch) long scale, for 120 percent of design flow rate, direct reading in L/s & gpm, with three valve manifold and two shut-off valves.

2.10 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 (1/8 inch) diameter perforations.

B. Suction Diffusers: Specified in Section 23 21 23, HYDRONIC PUMPS.

2.11 FLEXIBLE CONNECTORS FOR WATER SERVICE

A. Flanged Spool Connector:

1. Single arch or multiple arch type. Tube and cover shall be constructed of chlorobutyl elastomer with full faced integral flanges to provide a tight seal without gaskets. Connectors shall be internally reinforced with high strength synthetic fibers

impregnated with rubber or synthetic compounds as recommended by connector manufacturer, and steel reinforcing rings.

2. Working pressures and temperatures shall be as follows:
   a. Connector sizes 50 mm to 100 mm (2 inches to 4 inches), 1137 kPa (165 psig) at 121 degrees C (250 degrees F).
   b. Connector sizes 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.

2.12 EXPANSION JOINTS

A. Factory built devices, inserted in the pipelines, 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 pipelines to restrain lateral pipe motion and direct the axial pipe movement into the expansion joints.

B. Manufacturing Quality Assurance: Conform to Expansion Joints Manufacturers Association (EJMA) Standards.

C. Bellows - Internally Pressurized Type:
   1. Multiple corrugations of Type 304 or Type A240-321 stainless steel.
   2. Internal stainless-steel sleeve entire length of bellows.
   3. External cast iron equalizing rings for services exceeding 345 kPa (50 psig).
   4. Welded ends.
   5. Design shall conform to standards of EJMA and ASME B31.9.
   6. External tie rods designed to withstand pressure thrust force upon anchor failure if one or both anchors for the joint are at change in direction of pipeline.
   7. Integral external cover.

D. Bellows - Externally Pressurized Type:
   1. Multiple corrugations of Type 304 stainless steel.
   2. Internal and external guide integral with joint.
   3. Design for external pressurization of bellows to eliminate squirm.
   4. Welded ends.
   5. Conform to the standards of EJMA and ASME B31.9.
   6. Threaded connection at bottom, 25 mm (1 inch) minimum, for drain or drip point.
   7. Integral external cover and internal sleeve.

E. Expansion Compensators:
   1. Corrugated bellows, externally pressurized, stainless steel or bronze.
   2. Internal guides and anti-torque devices.
   3. Threaded ends.
   4. External shroud.
   5. Conform to standards of EJMA.

F. Expansion Joint (Contractor’s Option): 2413 kPa (350 psig) maximum working pressure, steel pipe fitting consisting of telescoping body and slip-pipe sections, PTFE modified polyphenylene sulfide coated slide section, with welded or flanged ends, suitable for axial end movement to 75 mm (3 inch).

G. Expansion Joint Identification: Provide stamped brass or stainless-steel nameplate on each expansion joint listing the manufacturer, the allowable movement, flow direction, design pressure and temperature, date of manufacture, and identifying the expansion joint by the identification number on the contract drawings.

H. Guides: Provide factory-built guides along the pipeline 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.

2.13 WATER FILTERS AND POT CHEMICAL FEEDERS

A. See Section 23 25 00, HVAC WATER TREATMENT, paragraph, CHEMICAL TREATMENT FOR CLOSED LOOP SYSTEMS.

2.14 GAUGES, PRESSURE AND COMPOUND

A. ASME B40.100, Accuracy Grade 1A, (pressure, vacuum, or compound for air, oil or water), initial mid-scale accuracy 1 percent of scale (Qualify grade), metal or phenolic case, 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 gauges in water service.

C. Range of Gauges: Provide range equal to at least 130 percent of normal operating range.

   1. For condenser water suction (compound): 101 kPa (30 inches Hg) to 690 kPa (100 psig).

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 gauge test connections shown on the drawings.

B. Provide one each of the following test items to the COR:

   1. 6 mm (1/4 inch) FPT by 3.2 mm (1/8 inch) diameter stainless steel pressure gauge adapter probe for extra-long test plug.
   2. 90 mm (3-1/2 inch) diameter, one percent accuracy, compound gauge, 101 kPa (30 inches Hg) to 690 kPa (100 psig) range.
   3. 0 to 104 degrees C (32 to 220 degrees F) pocket thermometer one-half degree accuracy, 25 mm (1 inch) dial, 125 mm (5 inch) long stainless-steel stem, plastic case.

2.16 THERMOMETERS

A. Mercury or 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.

B. Case: Chrome plated brass or aluminum with enamel finish.

C. Scale: Not less than 225 mm (9 inches), range as described below, two-degree graduations.

D. Separable Socket (Well): Brass, extension neck type to clear pipe insulation.

E. Scale ranges:

   1. Chilled Water and Glycol-Water: 0 to 38 degrees C (32 to 100 degrees F).
   2. Hot Water and Glycol-Water: 38 to 93 degrees C (100 to 200 degrees F).

2.17 ELECTRICAL HEAT TRACING SYSTEMS

A. Systems shall meet requirements of NFPA 70.

B. Provide tracing for outdoor piping subject to freezing temperatures below 3.3 degrees C (38 degrees F) as follows:
   1. Make-up water.
   2. Domestic water lines exposed to weather.
C. Heat tracing shall be provided to the extent shown on the drawings (Floor plans and Elevations). Heat tracing shall extend below grade to below the defined frost line.
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 40 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. 15 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, 15 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 degrees C (34 degrees F).
   4. Signs: Manufacturer's standard (NFPA 70), stamped "ELECTRIC TRACED" located on the insulation jacket at 3 m (10 feet) intervals along the pipe on alternating sides.

PART 3 - EXECUTION

3.1 GENERAL

A. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no additional cost or time to the Government.

B. The 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 or time to the Government. Coordinate with other trades for space available and relative location of HVAC equipment and accessories to be connected on ceiling grid. Pipe location on the drawings shall be altered by contractor where necessary to avoid interferences and clearance difficulties.

C. Store materials to avoid excessive exposure to weather or foreign materials. Keep inside of piping relatively clean during installation and protect open ends when work is not in progress.

D. Support piping securely. Refer to PART 3, Section 23 05 11, COMMON WORK RESULTS FOR HVAC. Install heat exchangers at height sufficient to provide gravity flow of condensate to the flash tank and condensate pump.

E. Install piping generally parallel to walls and column center lines, unless shown otherwise on the drawings. Space piping, including insulation, to provide 25 mm (1 inch) minimum clearance between adjacent piping or other surface. Unless shown otherwise, slope drain piping down in the direction of flow not less than 25 mm (1 inch) in 12 m (40 feet). Provide eccentric reducers to keep bottom of sloped piping flat.

F. Locate and orient valves to permit proper operation and access for maintenance of packing, seat and disc. Generally, locate valve stems in overhead piping in horizontal position. Provide a union adjacent to one end of all threaded end valves. Control valves usually require reducers to connect to pipe sizes shown on the drawing. Install butterfly valves with the valve open as recommended by the manufacturer to prevent binding of the disc in the seat.

G. Offset equipment connections to allow valving off for maintenance and repair with minimal removal of piping. Provide flexibility in equipment connections and branch line take-offs with 3-elbow swing joints where noted on the drawings.

H. Tee water piping runouts or branches into the side of mains or other branches. Avoid bull-head tees, which are two return lines entering opposite ends of a tee and exiting out the common side.

I. Provide manual or automatic air vent at all piping system high points and drain valves at all low points. Install piping to floor drains from all automatic air vents.

J. Connect piping to equipment as shown on the drawings. Install components furnished by others such as:

1. Water treatment pot feeders and condenser water treatment systems.
2. Flow elements (orifice unions), control valve bodies, flow switches, pressure taps with valve, and wells for sensors.

K. Thermometer Wells: In pipes 65 mm (2-1/2 inches) and smaller increase the pipe size to provide free area equal to the upstream pipe area.

L. Firestopping: Fill openings around uninsulated piping penetrating floors or fire walls, with firestop material. For firestopping insulated piping refer to Section 23 07 11, HVAC AND BOILER PLANT INSULATION.

M. Where copper piping is connected to steel piping, provide dielectric connections.

3.2 PIPE JOINTS

A. Welded: Beveling, spacing and other details shall conform to ASME B31.9 and AWS B2.1/B2.1M. See Welder’s qualification requirements under "Quality Assurance" in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

B. Screwed: Threads shall conform to ASME B1.20.1; joint compound shall be applied to male threads only and joints made up so no more than three threads show. Coat exposed threads on steel pipe with joint compound, or red lead paint for corrosion protection.

C. 125 Pound Cast Iron Flange (Plain Face): Mating flange shall have raised face, if any, removed to avoid overstressing the cast iron flange.

D. Solvent Welded Joints: As recommended by the manufacturer.

3.3 EXPANSION JOINTS (BELLOWS AND SLIP TYPE)

A. Anchors and Guides: Provide type, quantity and spacing as recommended by manufacturer of expansion joint and as shown. A professional engineer shall verify in writing that anchors and guides are properly designed for forces and moments which will be imposed.

B. Cold Set: Provide setting of joint travel at installation as recommended by the manufacturer for the ambient temperature during the installation.

C. Preparation for Service: Remove all apparatus provided to restrain joint during shipping or installation. Representative of manufacturer shall visit the site and verify that installation is proper.

D. Access: Expansion joints 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 SEISMIC BRACING ABOVEGROUND PIPING

A. Provide in accordance with Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

3.5 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.

3.6 FLUSHING AND CLEANING PIPING SYSTEMS

A. Water Piping: Clean systems as recommended by the suppliers of chemicals specified in Section 23 25 00, HVAC WATER TREATMENT.

B. Initial Flushing: Remove loose dirt, mill scale, metal chips, weld beads, rust, and like deleterious substances without damage to any system component. Provide temporary piping or hose to bypass coils, control valves, exchangers and other factory cleaned equipment unless acceptable means of protection are provided, and subsequent inspection of hide-out areas takes place. Isolate or protect clean system components, including pumps and pressure vessels, and remove any component which may be damaged. Open all valves, drains, vents and strainers at all system levels. Remove plugs, caps, spool pieces, and components to facilitate early debris discharge from system. Sectionalize system to obtain debris carrying velocity of 1.8 m/s (5.9 f/s), if possible. Connect dead-end supply and return headers as necessary. Flush bottoms of risers. Install temporary strainers where necessary to protect down-stream equipment. Supply and remove flushing water and drainage by various type hose, temporary and permanent piping and Contractor's booster pumps. Flush until clean as approved by the COR.

C. Cleaning: Using products supplied in Section 23 25 00, HVAC WATER TREATMENT, circulate systems at normal temperature to remove adherent organic soil, hydrocarbons, flux, pipe mill varnish, pipe joint compounds, iron oxide, and like deleterious substances not removed by flushing, without chemical or mechanical damage to any system component. Removal of tightly adherent mill scale is not required. Keep isolated equipment which is "clean" and where dead-end debris accumulation cannot occur. Sectionalize system, if possible, to circulate at velocities not less than 1.8 m/s (5.9 f/s). Circulate each section for not less than 4 hours. Blow-down all strainers or remove and clean as frequently as necessary. Drain and prepare for final flushing.

D. Final Flushing: Return systems to conditions required by initial flushing after all cleaning solution has been displaced by clean make-up. Flush all dead ends and isolated clean equipment. Gently operate all valves to dislodge any debris in valve body by throttling velocity. Flush for not less than one hour.

3.7 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.

3.8 ELECTRIC HEAT TRACING

A. Install tracing as recommended by the manufacturer.

B. Coordinate electrical connections.

3.9 STARTUP AND TESTING

A. Perform tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.

B. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.

C. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with COR and Commissioning Agent. Provide a minimum notice of 10 working days prior to startup and testing.

D. Adjust red set hand on pressure gauges to normal working pressure.

3.10 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

B. Components provided under this section of the specification will be tested as part of a larger system.

3.11 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer’s technical representative for 4 hours to instruct each VA personnel responsible in operation and maintenance of the system.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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SECTION 23 22 23
STEAM CONDENSATE PUMPS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Steam condensate pumps for Heating, Ventilating and Air Conditioning.

B. Definitions:

1. Capacity: Liters per second (L/s) (Gallons per minute (gpm)) of the fluid pumped.
2. Head: Total dynamic head in kPa (feet) of the fluid pumped.

C. A complete listing of common acronyms and abbreviations are included in Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION; Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

D. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

E. Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION.

F. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

G. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT.

H. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.

I. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

J. Section 23 22 13, STEAM AND CONDENSATE HEATING PIPING.

1.3 SUBMITTALS

A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Information and material submitted under this section shall be marked "SUBMITTED UNDER SECTION 23 22 23, STEAM CONDENSATE PUMPS", with applicable paragraph identification.

C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.
   1. Pumps and accessories.
   2. Motors and drives.
D. Characteristic Curves: Head-capacity, efficiency-capacity, brake horsepower-capacity, and NPSHR-capacity for each pump and if specified, for dual parallel pump operation.
E. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replacement parts, and troubleshooting guide:
   1. Include complete list indicating all components of the systems.
   2. Include complete diagrams of the internal wiring for each item of equipment.
   3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.
F. Completed System Readiness Checklist provided by the 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.
G. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

1.4 QUALITY ASSURANCE

A. 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 electric-powered 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.
9. Furnish one spare seal and casing gasket for each pump to the COR.

B. Allowable Vibration Tolerance for Pump Units: Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING AND EQUIPMENT.

1.5 AS-BUILT DOCUMENTATION

A. Submit manufacturer’s literature and data updated to include submittal review comments and any equipment substitutions.

B. Submit operation and maintenance data updated to include submittal review comments, VA approved substitutions and construction revisions shall be in electronic version on CD or DVD inserted into a three-ring binder. All aspects of system operation and maintenance procedures, including applicable piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices shall be included. A List of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.

C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the 'third party testing company' requirement. Provide record drawings as follows:

1. As-built drawings are to be provided, with a copy of them on AutoCAD provided on CD or DVD. The CAD drawings shall use multiple line layers with a separate individual layer for each system.

D. The as-built drawings shall indicate the location and type of all lockout/tagout points for all energy sources for all equipment and pumps to include breaker location and numbers, valve tag numbers, etc. Coordinate lockout/tagout procedures and practices with local VA requirements.

E. Certification documentation shall be provided to COR 21 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and provide documentation/certification that all results of tests were within limits specified. Test results shall contain written sequence of test procedure with written test results annotated at each step along with the expected outcome or setpoint. The results shall include all readings, including but not limited to data on device (make, model and performance characteristics), normal pressures, switch ranges, trip points, amp readings, and calibration data to include equipment serial numbers or individual identifications, etc.

1.6 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only:

B. American Iron and Steel Institute (AISI):

AISI 1045 2013..........Cold Drawn Carbon Steel Bar, Type 1045

AISI 416 2016...........Type 416 Stainless Steel

C. American National Standards Institute (ANSI):

ANSI B15.1-2000....Safety Standard for Mechanical Power Transmission Apparatus

ANSI B16.1-2015.........Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250 and 800

D. American Society for Testing and Materials (ASTM):

A48-2016................Standard Specification for Gray Iron Castings

B62-2016................Standard Specification for Composition Bronze or Ounce Metal Castings

E. Maintenance and Operating Manuals in accordance with Section 01 00 00, GENERAL REQUIREMENTS.

PART 2 - PRODUCTS

2.1 CONDENSATE PUMP, PAD-MOUNTED

A. General: Factory assembled unit consisting of vented receiver tank, motor-driven pumps, interconnecting piping and wiring, motor controls (including starters, if necessary) and accessories, designed to receive, store, and pump steam condensate.

B. Receiver Tank: Cast iron with threaded openings for connection of piping and accessories and facilities for mounting float switches. Receivers for simplex pumps shall include all facilities for future mounting of additional pump and controls.

C. Furnish seals for condensate pump with a minimum temperature rating of 121 degrees C (250 degrees F).

D. Centrifugal Pumps: Bronze fitted with mechanical shaft seals.

1. Designed to allow removal of rotating elements without disturbing connecting piping or pump casing mounting.
2. Shafts: Stainless steel, Type 416 or alloy steel with bronze shaft sleeves.
3. Bearings: Regreaseable ball or roller type.
4. Casing wearing rings: Bronze.

E. Motors: Refer to Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC AND STEAM GENERATION EQUIPMENT.

F. Pump Operation:

1. Float Switches: NEMA 4, mounted on receiver tank, to start and stop pumps in response to changes in the water level in the receiver and adjustable to permit the controlled water levels to be changed. Floats and connecting rods shall be copper, bronze or stainless steel.
2. Alternator: Provide for duplex units to automatically start the second pump when the first pump fails in keeping the receiver water level from rising and to alternate the order of starting the pumps

to equalize wear. For units 0.25 kW (1/3 hp) and smaller, the alternator may be the mechanical type for use in lieu of float switches.

G. Control Cabinet for 3 Phase (0.37 kW (1/2 hp) and larger) Units: NEMA 4, UL approved, factory wired, enclosing all controls, with indicating lights, manual switches and resets mounted on the outside of the panel. Attach cabinet to the pump set with rigid steel framework, unless remote mounting is noted on the pump schedule.
   1. Motor starters: Magnetic contact types with circuit breakers or combination fusible disconnect switches. Provide low voltage control circuits (120-volt maximum) and HOA switches for each pump.
   2. Indicating lights for each pump: Green to show that power is on, red to show that the pump is running.

H. Electric Wiring: Suitable for 94 degrees C (200 degrees F) service; enclosed in liquid-tight flexible metal conduit where located outside of control cabinet.

I. Receiver Accessories:
   1. Thermometer: 38 to 216 degrees C (100 to 420 degrees F), mounted below minimum water level.
   2. Water level gauge glass: Brass with gauge cocks which automatically stop the flow of water when the glass is broken. Provide drain on the lower gauge cock and protection rods for the glass.

PART 3 - EXECUTION

3.1 INSTALLATION

A. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no additional cost or time to the Government.

B. Follow manufacturer's written instructions for pump mounting and startup. Access/Service space around pumps shall not be less than minimum space recommended by pumps manufacturer.

C. 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.

E. Sump Type Condensate Pump: Apply two coats of asphalt or bituminous compound on the exterior of the receiver tank, and mount level and flush in the floor with waterproofing gaskets and grouting to prevent ground water from entering the building from around the receiver.

F. Coordinate location of thermometer and pressure gauges as per Section 23 22 13, STEAM AND CONDENSATE HEATING PIPING.

3.2 STARTUP AND TESTING

A. Perform tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.

B. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.

C. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with COR and Commissioning Agent. Provide a minimum notice of 10 working days prior to startup and testing.

D. Verify that the piping system has been flushed, cleaned and filled.

E. Lubricate pumps before startup.

F. Prime the pump, vent all air from the casing and verify that the rotation is correct. To avoid damage to mechanical seals, never start or run the pump in dry condition.

G. Verify that correct size heaters-motor over-load devices are installed for each pump controller unit.

H. Field modifications to the bearings and or impeller (including trimming) are prohibited. If the pump does not meet the specified vibration tolerance send the pump back to the manufacturer for a replacement pump. All modifications to the pump shall be performed at the factory.

3.3 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

B. Components provided under this section of the specification will be tested as part of a larger system.

3.4 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer’s technical representative for 4 hours to instruct each VA personnel responsible in operation and maintenance of the system.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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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 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

D. Section 23 07 11, HVAC, and BOILER PLANT INSULATION.

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 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 support
   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.

D. Design Manual: Furnish two copies of design manual of refrigerant valves and accessories.

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 (ARI/AHRI):

495-2005................Standard for Refrigerant Liquid Receivers

730-2013................Flow Capacity Rating of Suction-Line Filters and Suction-Line Filter-Driers

750-2016................Thermostatic Refrigerant Expansion Valves

760-202014..............Performance Rating of Solenoid Valves for Use with Volatile Refrigerants

C. American Society of Heating Refrigerating and Air Conditioning Engineers (ASHRAE):

15-2019.................Safety Standard for Refrigeration Systems (ANSI)

17-2008.................Method of Testing Capacity of Thermostatic Refrigerant Expansion Valves (ANSI)

63.1-2001...............Method of Testing Liquid Line Refrigerant Driers (ANSI)

63.2-2010...............Method of Testing Liquid Line Filter Drier Filtration Capability (ANSI)

D. American National Standards Institute (ANSI):

A13.1-2015Scheme for Identification of Piping Systems

Z535.1-2017.............Safety Color Code

E. American Society of Mechanical Engineers (ASME):

B16.22-2018 Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings (ANSI)

B16.24-20016Cast Copper Alloy Pipe Flanges and Flanged Fittings, Class 150, 300, 400, 600, 900, 1500 and 2500 (ANSI)

B31.5-2013 Refrigeration Piping and Heat Transfer Components (ANSI)

B40.100-2013............Pressure Gauges and Gauge Attachments

B40.200-2008............Thermometers, Direct Reading and Remote Reading

F. American Society for Testing and Materials (ASTM)

A126-2014...............Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings

B32-08Standard Specification for Solder Metal

B88-2016................Standard Specification for Seamless Copper Water Tube

B88M-2018...............Standard Specification for Seamless Copper Water Tube (Metric)

B280-2019...............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-2011.........Standard Specification for Filler Metals for Brazing and Braze Welding

H. Underwriters Laboratories (U.L.):

U.L.207-018.............Standard for Refrigerant-Containing Components and Accessories, Nonelectrical

U.L.429-2013............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 B88M, Type B or C (ASTM B88, Type M or L). Optional drain piping material: Schedule 80 flame retardant Polypropylene plastic.

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.
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 open or closed holding coil.

d. Thermostatic Expansion Valves: Comply with ARI 750. Brass body with stainless-steel or non-corrosive nonferrous internal parts, diaphragm and spring-loaded (direct-operated) type with sensing bulb and distributor having side connection for hot-gas bypass and external equalizer. Size and operating characteristics as recommended by manufacturer of evaporator and factory set for superheat requirements. Solder-end connections. Testing and rating in accordance with ASHRAE Standard 17.

e. 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 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. Oil Separators: Provide for condensing units, as shown. All welded steel construction with capacity to eliminate a minimum of 95 percent of the oil from the hot gas flowing through it. Provide manufacturer's published ratings for minimum and maximum refrigeration tonnage corresponding to this oil separating efficiency. Separator shall be equipped with a float valve to prevent return of the hot gas to crankcase and shall have isolating stop valves so it can be opened and services without pumping out any other part of the system. ASME construction or UL listed.
10. Receivers: Conform to AHRI 495, steel construction, equipped with taps for liquid inlet and outlet valves, pressure relief valve and liquid level indicator.

2.2 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 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.

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.
2. Install piping with adequate clearance between pipe and adjacent walls and hangers to allow for service and inspection. Space piping, including insulation, to provide 25 mm (1 inch) minimum clearance between adjacent piping or other surface. Use pipe sleeves through walls, floors, and ceilings, sized to permit installation of pipes with full thickness insulation.
3. Locate and orient valves to permit proper operation and access for maintenance of packing, seat and disc. Generally, locate valve stems in overhead piping in horizontal position. Provide a union adjacent to one end of all threaded end valves. Control valves usually require reducers to connect to pipe sizes shown on the drawing.
4. Use copper tubing in protective conduit when installed below ground.
5. Install hangers and supports per ASME B31.5 and the refrigerant piping manufacturer's recommendations.

B. Joint Construction:

1. Brazed Joints: Comply with AWS "Brazing Handbook" and with filler materials complying with AWS A5.8/A5.8M.
   a. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper tubing.
   b. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.
   c. Swab fittings and valves with manufacturer's recommended cleaning fluid to remove oil and other compounds prior to installation.
   d. Pass nitrogen gas through the pipe or tubing to prevent oxidation as each joint is brazed. Cap the system with a reusable plug after each brazing operation to retain the nitrogen and prevent entrance of air and moisture.

C. Protect refrigerant system during construction against entrance of foreign matter, dirt and moisture; have open ends of piping and connections to compressors, condensers, evaporators and other equipment tightly capped until assembly.

D. Pipe relief valve discharge to outdoors for systems containing more than 45 kg (100 lbs) of refrigerant.

E. Firestopping: Fill openings around uninsulated piping penetrating floors or fire walls, with firestop material. For firestopping insulated piping refer to Section 23 07 11, HVAC, and BOILER PLANT INSULATION.

F. Seismic Bracing: Refer to specification Section 13 05 41, SEISMIC RESTRAINTS REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS, for bracing of piping in seismic areas.

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

A. Prior to initial operation examine and inspect piping system for conformance to plans and specifications and ASME B31.5. Correct equipment, material, or work rejected because of defects or nonconformance with plans and specifications, and ANSI codes for pressure piping.

B. After completion of piping installation and prior to initial operation, conduct test on piping system according to ASME B31.5. Furnish materials and equipment required for tests. Perform tests in the presence of COR. If the test fails, correct defects and perform the test again until it is satisfactorily done and all joints are proved tight.

1. Every refrigerant-containing parts of the system that is erected on the premises, except compressors, condensers, evaporators, safety devices, pressure 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.

C. Test Medium: A suitable dry gas such as nitrogen or shall be used for pressure testing. The means used to build up test pressure shall have either a pressure-limiting device or pressure-reducing device with a pressure-relief device and a 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

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 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, .

1.2 RELATED WORK

A. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.

B. Section 07 84 00, FIRESTOPPING: Fire Stopping Material.

C. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS: Seismic Reinforcing.

D. Section 22 11 00, FACILITY WATER DISTRIBUTION: Plumbing Connections.

E. Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT.

F. Section 23 05 11, COMMON WORK RESULTS FOR HVAC: General Mechanical Requirements.

G. Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT: Noise Level Requirements.

H. Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC: Testing and Balancing of Air Flows.

I. Section 23 07 11, HVAC, and BOILER PLANT INSULATION: Duct Insulation.

J. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC: Duct Mounted Instrumentation.

K. Section 23 34 00, HVAC FANS: Return Air and Exhaust Air Fans.

L. Section 23 40 00, HVAC AIR CLEANING DEVICES: Air Filters and Filters' Efficiencies.

M. Section 23 82 16, AIR COILS: Duct Mounted Coils.

N. Section 28 31 00, FIRE DETECTION and ALARM: Smoke Detectors.

1.3 QUALITY ASSURANCE

A. Refer to article, QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

B. Fire Safety Code: Comply with NFPA 90A.

C. Duct System Construction and Installation: Referenced SMACNA Standards are the minimum acceptable quality.

D. Duct Sealing, Air Leakage Criteria, and Air Leakage Tests: Ducts shall be sealed as per duct sealing requirements of SMACNA HVAC Air Duct Leakage Test Manual for duct pressure classes shown on the drawings.

E. Duct accessories exposed to the air stream, such as dampers of all types (except smoke dampers) and access openings, shall be of the same material as the duct or provide at least the same level of corrosion resistance.

1.4 SUBMITTALS

A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.

B. Manufacturer's Literature and Data:

1. Rectangular ducts:
   a. Schedules of duct systems, materials and selected SMACNA construction alternatives for joints, sealing, gage and reinforcement.
   b. Duct liner.
   c. Sealants and gaskets.
   d. Access doors.
2. Round and flat oval duct construction details:
   a. Manufacturer's details for duct fittings.
   b. Duct liner.
   c. Sealants and gaskets.
   d. Access sections.
   e. Installation instructions.
3. Volume dampers, back draft dampers.
4. Upper hanger attachments.

5. Fire dampers, fire doors, and smoke dampers with installation instructions.
6. 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.
11 COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.

C. Coordination Drawings: Refer to article, SUBMITTALS, in Section 23 05 11-COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION.

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):

ASCE7-2017..............Minimum Design Loads for Buildings and Other Structures

C. American Society for Testing and Materials (ASTM):

A167-2009...............Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip

A653-2019...............Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy coated (Galvannealed) by the Hot-Dip process

A1011-2018..............Standard Specification for Steel, Sheet and Strip, Hot rolled, Carbon, structural, High-Strength Low-Alloy, High Strength Low-Alloy with Improved Formability, and Ultra-High Strength

B209-2014...............Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate

C1071-2019..............Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)

E84-2014................Standard Test Method for Surface Burning Characteristics of Building Materials

D. National Fire Protection Association (NFPA):

90A-2018................Standard for the Installation of Air Conditioning and Ventilating Systems

96-2018.................Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations

E. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):

3rd Edition –2006.......HVAC Duct Construction Standards, Metal and Flexible

2nd Edition -2012.......HVAC Air Duct Leakage Test Manual

6th Edition –2016.......Fibrous Glass Duct Construction Standards

F. Underwriters Laboratories, Inc. (UL):

181-2013................Factory-Made Air Ducts and Air Connectors

555-2006 ....Standard for Fire Dampers

555S-2014...............Standard for Smoke Dampers

PART 2 - PRODUCTS

2.1 DUCT MATERIALS AND SEALANTS

A. General: Except for systems specified otherwise, construct ducts, casings, and accessories of galvanized sheet steel, ASTM A653, coating G90; or, aluminum sheet, ASTM B209, alloy 1100, 3003 or 5052.

B. 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. Optional Duct Materials:

1. Grease Duct: Double wall factory-built grease duct, UL labeled and complying with NFPA 96 may be furnished in lieu of specified materials for kitchen and grill hood exhaust duct. Installation and accessories shall comply with the manufacturers catalog data. Outer jacket of exposed ductwork shall be stainless steel. Square and rectangular duct shown on the drawings will have to be converted to equivalent round size.

D. Joint Sealing: Refer to SMACNA HVAC Duct Construction Standards.

1. Sealant: Elastomeric compound, gun or brush grade, maximum 25 flame spread, and 50 smoke developed (dry state) compounded specifically for sealing ductwork as recommended by the manufacturer. Generally, provide liquid sealant, with or without compatible tape, for low clearance slip joints and heavy, permanently elastic, mastic type where clearances are larger. Oil base caulking and glazing compounds are not acceptable because they do not retain elasticity and bond.
2. Tape: Use only tape specifically designated by the sealant manufacturer and apply only over wet sealant. Pressure sensitive tape shall not be used on bare metal or on dry sealant.
3. Gaskets in Flanged Joints: Soft neoprene.

E. Approved factory-made joints may be used.

2.2 DUCT CONSTRUCTION AND INSTALLATION

A. Regardless of the pressure classifications outlined in the SMACNA Standards, fabricate and seal the ductwork in accordance with the following pressure classifications:

B. Duct Pressure Classification:

0 to 50 mm (2 inch)

> 50 mm to 75 mm (2 inch to 3 inch)

> 75 mm to 100 mm (3 inch to 4 inch)

Show pressure classifications on the floor plans.

C. Seal Class: All ductwork shall receive Class A Seal

D. Duct for Negative Pressure Up to 750 Pa (3-inch W.G.): Provide for exhaust duct between HEPA filters and exhaust fan inlet including systems for Autopsy Suite exhaust.

1. Round Duct: Galvanized steel, spiral lock seam construction with standard slip joints.
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.

E. Round and Flat Oval Ducts: Furnish duct and fittings made by the same manufacturer to insure good fit of slip joints. When submitted and approved in advance, round and flat oval duct, with size converted on the basis of equal pressure drop, may be furnished in lieu of rectangular duct design shown on the drawings.

1. Elbows: Diameters 80 through 200 mm (3 through 8 inches) shall be two sections die stamped, all others shall be gored construction, maximum 18 degree angle, with all seams continuously welded or standing seam. Coat galvanized areas of fittings damaged by welding with corrosion resistant aluminum paint or galvanized repair compound.
2. Provide bell mouth, conical tees or taps, laterals, reducers, and other low loss fittings as shown in SMACNA HVAC Duct Construction Standards.
3. Ribbed Duct Option: Lighter gage round/oval duct and fittings may be furnished provided certified tests indicating that the rigidity and performance is equivalent to SMACNA standard gage ducts are submitted.
   a. Ducts: Manufacturer's published standard gage, G90 coating, spiral lock seam construction with an intermediate standing rib.
   b. Fittings: May be manufacturer's standard as shown in published catalogs, fabricated by spot welding and bonding with neoprene base cement or machine formed seam in lieu of continuous welded seams.
4. Provide flat side reinforcement of oval ducts as recommended by the manufacturer and SMACNA HVAC Duct Construction Standard S3.13. Because of high pressure loss, do not use internal tie-rod reinforcement unless approved by the COR.

F. 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.

G. Volume Dampers: Single blade or opposed blade, multi-louver type as detailed in SMACNA Standards. Refer to SMACNA for Single Blade and Figure 2.13 for Multi-blade Volume Dampers.

H. Duct Hangers and Supports: Refer to SMACNA Standards Section IV. Avoid use of trapeze hangers for round duct.

I. Ductwork in excess of 620 cm^2 (96 square inches) shall be protected unless the duct has one dimension less than 150 mm (6 inches) if it passes through the areas listed below. Refer to the Mission Critical Physical Design Manual for VA Facilities. This applies to the following:

1. Agent cashier spaces
2. Perimeter partitions of caches
3. Perimeter partitions of computer rooms
4. Perimeter of a COOP sites
5. Perimeter partitions of Entrances
6. Security control centers (SCC)

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.
4. For cleaning operating room supply air duct and kitchen hood exhaust duct, locate access doors at 6 m (20 feet) intervals and at each change in duct direction.

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 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.

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:

1. Temperature range: -18 to 93 degrees C (0 to 200 degrees F) internal.
2. Maximum working velocity: 1200 m/min (4000 feet per minute).

3. Minimum working pressure, inches of water gage: 2500 Pa (10 inches) positive, 500 Pa (2 inches) negative.

E. Duct Clamps: 100 percent nylon strap, 80 kg (175 pounds) minimum loop tensile strength manufactured for this purpose or stainless-steel strap with cadmium plated worm gear tightening device. Apply clamps with sealant and as approved for UL 181, Class 1 installation.

2.9 FLEXIBLE DUCT CONNECTIONS

A. Where duct connections are made to fans, air terminal units, and air handling units, install a non-combustible flexible connection of 822 g (29 ounce) neoprene coated fiberglass fabric approximately 150 mm (6 inches) wide. For connections exposed to sun and weather provide hypalon coating in lieu of neoprene. Burning characteristics shall conform to NFPA 90A. Securely fasten flexible connections to round ducts with stainless steel or zinc-coated iron draw bands with worm gear fastener. For rectangular connections, crimp fabric to sheet metal and fasten sheet metal to ducts by screws 50 mm (2 inches) on center. Fabric shall not be stressed other than by air pressure. Allow at least 25 mm (one inch) slack to ensure that no vibration is transmitted.

2.10 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.

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 PREFABRICATED ROOF CURBS

A. Galvanized steel or extruded aluminum 300 mm (12 inches) above finish roof service, continuous welded corner seams, treated wood nailer, 40 mm (1-1/2 inch) thick, 48 kg/cubic meter (3 pound/cubic feet) density rigid mineral fiberboard insulation with metal liner, built-in can't strip (except for gypsum or tectum decks). For surface insulated roof deck, provide raised cant strip (recessed mounting flange) to start at the upper surface of the insulation. Curbs shall be constructed for pitched roof or ridge mounting as required to keep top of curb level.

2.12 FIRESTOPPING MATERIAL

A. Refer to Section 07 84 00, FIRESTOPPING.

2.13 SEISMIC RESTRAINT FOR DUCTWORK

A. Refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

2.14 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.

2.15 DUCT MOUNTEDTEMPERATURE SENSOR (AIR)

A. Refer to Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

2.16 INSTRUMENT TEST FITTINGS

A. Manufactured type with a minimum 50 mm (two inch) length for insulated duct, and a minimum 25 mm (one inch) length for duct not insulated. Test hole shall have a flat gasket for rectangular ducts and a concave gasket for round ducts at the base, and a screw cap to prevent air leakage.

B. Provide instrument test holes at each duct or casing mounted temperature sensor or transmitter, and at entering and leaving side of each heating coil, cooling coil, and heat recovery unit.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with provisions of Section 23 05 11, COMMON WORK RESULTS FOR HVAC, particularly regarding coordination with other trades and work in existing buildings.

B. Fabricate and install ductwork and accessories in accordance with referenced SMACNA Standards:

1. Drawings show the general layout of ductwork and accessories but do not show all required fittings and offsets that may be necessary to connect ducts to equipment, boxes, diffusers, grilles, etc., and to coordinate with other trades. Fabricate ductwork based on field measurements. Provide all necessary fittings and offsets at no additional cost to the government. Coordinate with other trades for space available and relative location of HVAC equipment and accessories on ceiling grid. Duct sizes on the drawings are inside dimensions which shall be altered by Contractor to other dimensions with the same air handling characteristics where necessary to avoid interferences and clearance difficulties.
2. Provide duct transitions, offsets and connections to dampers, coils, and other equipment in accordance with SMACNA Standards. Provide streamliner, when an obstruction cannot be avoided and must be taken in by a duct. Repair galvanized areas with galvanizing repair compound.
3. Provide bolted construction and tie-rod reinforcement in accordance with SMACNA Standards.
4. Construct casings, eliminators, and pipe penetrations in accordance with SMACNA Standards, 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.

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 hours. 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.
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. Low Pressure Duct Liner: Install in accordance with SMACNA, Duct Liner Application Standard.

K. Protection and Cleaning: Adequately protect equipment and materials against physical damage. Place equipment in first class operating condition or return to source of supply for repair or replacement, as determined by COR. Protect equipment and ducts during construction against entry of foreign matter to the inside and clean both inside and outside before operation and painting. When new ducts are connected to existing ductwork, clean both new and existing ductwork by mopping and vacuum cleaning inside and outside before operation.

3.2 DUCT LEAKAGE TESTS AND REPAIR

A. Ductwork leakage testing shall be performed by the Testing and Balancing Contractor directly contracted by the General Contractor and independent of the Sheet Metal Contractor.

B. Ductwork leakage testing shall be performed for the entire air distribution system (including all supply, return, exhaust and relief ductwork), section by section, including fans, coils and filter sections. Based upon satisfactory initial duct leakage test results, the scope of the testing may be reduced by the COR on ductwork constructed to the 500 Pa (2" WG) duct pressure classification. In no case shall the leakage testing of ductwork constructed above the 500 Pa (2" WG) duct pressure classification or ductwork located in shafts or other inaccessible areas be eliminated.

C. Test procedure, apparatus and report shall conform to SMACNA Leakage Test manual. The maximum leakage rate allowed is 4 percent of the design air flow rate.

D. All ductwork shall be leak tested first before enclosed in a shaft or covered in other inaccessible areas.

E. All tests shall be performed in the presence of the COR and the Test and Balance agency. The Test and Balance agency shall measure and record duct leakage and report to the COR and identify leakage source with excessive leakage.

F. If any portion of the duct system tested fails to meet the permissible leakage level, the Contractor shall rectify sealing of ductwork to bring it into compliance and shall retest it until acceptable leakage is demonstrated to the COR.

G. All tests and necessary repairs shall be completed prior to insulation or concealment of ductwork.

H. Make sure all openings used for testing flow and temperatures by TAB Contractor are sealed properly.

3.3 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__185__km/h (_115_mph).

3.4 TESTING, ADJUSTING AND BALANCING (TAB)

A. Refer to Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC.

3.5 OPERATING AND PERFORMANCE TESTS

A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

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SECTION 23 34 00
HVAC FANS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Fans for heating, ventilating and air conditioning.

B. Product Definitions: AMCA Publication 99, Standard l-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 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

D. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

E. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION EQUIPMENT.

F. Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.

G. Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC.

H. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

I. Section 23 81 00, DECENTRALIZED UNITARY HVAC EQUIPMENT.

J. 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.

B. Fans and power ventilators shall be listed in the current edition of AMCA 26l and shall bear the AMCA performance seal.

C. Operating Limits for Centrifugal Fans: AMCA 99 (Class I, II, and III).

D. Fans and power ventilators shall comply with the following standards:

1. Testing and Rating: AMCA 2l0.
2. Sound Rating: AMCA 300.

E. Vibration Tolerance for Fans and Power Ventilators: Section 23 05 41, NOISE AND VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.

F. Performance Criteria:

1. The fan schedule shall show the design air volume and static pressure. Select the fan motor HP by increasing the fan BHP by 10 percent to account for the drive losses and field conditions.
2. Select the fan operating point as follows:

a. Forward Curve and Axial Flow Fans: Right hand side of peak pressure point
b. Air Foil, Backward Inclined, or Tubular: At or near the peak static efficiency

G. Safety Criteria: Provide manufacturer's standard screen on fan inlet and discharge where exposed to operating and maintenance personnel.

H. Corrosion Protection:

1. Except for fans in fume hood exhaust service, all steel shall be mill-galvanized, or phosphatized and coated with minimum two coats, corrosion resistant enamel paint. Manufacturers paint and paint system shall meet the minimum specifications of: ASTM D1735 water fog; ASTM B117 salt spray; ASTM D3359 adhesion; and ASTM G152 and G153 for carbon arc light apparatus for exposure of non-metallic material.
2. Fans for general purpose fume hoods, or chemical hoods, and radioisotope hoods shall be constructed of materials compatible with the chemicals being transported in the air through the fan.

I. Spark resistant construction: If flammable gas, vapor or combustible dust is present in concentrations above 20% of the Lower Explosive Limit (LEL), the fan construction shall be as recommended by AMCA's Classification for Spark Resistant Construction. Drive set shall be comprised of non-static belts for use in an explosive.

1.4 SUBMITTALS

A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.

B. Manufacturers Literature and Data:

1. Fan sections, motors and drives.
2. Centrifugal fans, motors, drives, accessories and coatings.
   a. In-line centrifugal fans.
   b. Tubular Centrifugal Fans.
   c. Up-blast kitchen hood exhaust fans.
   d. Industrial fans.
   e. Utility fans and vent sets.
3. Prefabricated roof curbs.
4. Power roof and wall ventilators.
5. Centrifugal ceiling fans.
6. Propeller fans.

7. Packaged hood make-up air units.
8. Vane axial fans.
9. Tube-axial 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):

99-2016.................Standards Handbook
210-2016................Laboratory Methods of Testing Fans for Aerodynamic Performance Rating
261-2017................Directory of Products Licensed to bear the AMCA Certified Ratings Seal - Published Annually
300-2014................Reverberant Room Method for Sound Testing of Fans

C. American Society for Testing and Materials (ASTM):

B117-2018...............Standard Practice for Operating Salt Spray (Fog) Apparatus
D1735-2008..............Standard Practice for Testing Water Resistance of Coatings Using Water Fog Apparatus
D3359-2017..............Standard Test Methods for Measuring Adhesion by Tape Test
G152-2013...............Standard Practice for Operating Open Flame Carbon Arc Light Apparatus for Exposure of Non-Metallic Materials
G153-2013...............Standard Practice for Operating Enclosed Carbon Arc Light Apparatus for Exposure of Non-Metallic Materials

D. National Fire Protection Association (NFPA):

NFPA 96-2018............Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations

E. National Sanitation Foundation (NSF):

37-2017 ....Air Curtains for Entrance Ways in Food and Food Service Establishments

F. Underwriters Laboratories, Inc. (UL):

181-2013................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

2.2 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 l, 3, 9 or l0.

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 Bl0 life of not less than 50,000 hours, and an average fatigue life of 200,000 hours. Extend filled lubrication tubes for interior bearings or ducted units to outside of housing.
5. Belts: Oil resistant, non-sparking and non-static.
6. Belt Drives: Factory installed with final alignment belt adjustment made after installation.

7. Motors and Fan Wheel Pulleys: Adjustable pitch for use with motors through 15HP, fixed pitch for use with motors larger than 15HP. Select pulleys so that pitch adjustment is at the middle of the adjustment range at fan design conditions.
8. Motor, adjustable motor base, drive and guard: Furnish from factory with fan. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC 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 26 29 11, MOTOR STARTERS. 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. Provide factory wired disconnect switch.

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. Utility Fans, Vent Sets and Small Capacity Fans: Class l design, arc welded housing, spun intake cone. Applicable construction specification, paragraphs A and C, for centrifugal fans shall apply for wheel diameters 300 mm (l2 inches) and larger. Requirement for AMCA seal is waived for wheel diameters less than 300 mm (l2 inches) and housings may be cast iron.

G. Spark Resistant/Explosion Proof Fans: If flammable gas, vapor or combustible dust is present in concentrations above 20% of the Lower Explosive Limit (LEL), provide AMCA construction option: A, B or C as indicated. Drive set shall be comprised of non-static belts for use in an explosive atmosphere. Motor shall be explosion proof type if located in air stream.

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 servicing, aluminum bird screen on discharge, UL approved safety disconnect switch, conduit for wiring, vibration isolators for wheel, motor and drive assembly. Provide self-acting back draft damper.

D. Motor and Drive: Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC. 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.

F. Up-blast Type: Top discharge exhauster, motor out of air stream. life of 200,000 hours. Motor shall be located out of air stream.

2.5 PACKAGED HOOD MAKE-UP AIR UNITS

A. Curb mounted air supply unit complete with centrifugal blower and filters.

   1. Housing: Galvanized steel with baffled air intake for weather protection and with duct adapter.
   2. Blower: Ball bearing utility type with vibration mounts to isolate blower, motor and drive.
   3. Prefabricated roof curb: As specified in paragraph 2.3 of this section.
   4. Filters: Provide four 2” MERV 8 disposable filters

B. Provide easy access to motor and drive.

C. Provide electric heating coil where scheduled. Refer to specification Section 23 82 16, AIR COILS.

2.6 CENTRIFUGAL CEILING FANS (SMALL CABINET FAN)

A. Standards and Performance Criteria: Refer to Paragraph, QUALITY ASSURANCE.

B. Steel housing, baked enamel finish, direct connected fan assembly, attached grille. Provide gravity back draft assembly, aluminum wall cap and bird or insect screen. Provide electric motor operated damper where indicated.

C. Acoustical Lining: 12.5 mm (1/2 inch) thick mineral fiber, dark finish. Comply with UL 181 for erosion.

D. Motor: Shaded pole or permanent split capacitor, sleeve bearings, supported by steel brackets in combination with rubber isolators.

E. Ceiling Grille, (Where indicated): White plastic egg crate design, 80 percent free area.

F. Control: Provide solid state speed control (located at unit) for final air balancing.

2.7 PROPELLER FANS

A. Standards and Performance Criteria: Refer to Paragraph, QUALITY ASSURANCE.

B. Belt-driven or direct-driven fans as indicated on drawings.

C. Square steel panel, deep drawn venturi, arc welded to support arms and fan/motor support brackets, baked enamel finish. Provide wall collar for thru-wall installations.

D. Motor, Motor Base and Drive: Refer to Section 23 05 11, COMMON WORK RESULTS. Motor shall be totally enclosed type.

E. Wall Shutter: Fan manufacturer's standard, steel frame, aluminum blades, heavy duty stall type electric damper motor, spring closed.

F. Wire Safety Guards: Provide on exposed inlet and outlet.

2.8 VANE AXIAL FANS

A. Standards and Performance Criteria: Refer to Paragraph, QUALITY ASSURANCE. The requirements for AMCA listing and seal are waived.

B. Fan 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.

C. Impeller: Heat treated cast aluminum alloy incorporating airfoil blades. Impellers shall be balanced statically and dynamically prior to installation on the shaft and as an integral unit prior to shipment.

D. Variable Pitch Type: Pitch of all blades shall be continuously and simultaneously adjustable throughout the complete pitch range while the impeller is operating at full speed. Blade pitch adjustment shall be accomplished by a factory furnished, mounted, adjusted and tested pneumatic operator with positive positioner relay. Signal pressure shall be 100 kPa (15 psig) and operating pressure shall be 450 kPa to 550 kPa (65 to 80 psig).

E. Fan Drive: Direct drive or belt drive as scheduled, arrangement 4, with motor located inside fan housing on discharge side of impeller, NEMA C motor mounting, bearings B-10 with average operating life of 200,000 hours, motor wiring leads and bearing lubrication lines extended to outside of housing. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC for motor specifications.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install fan, motor and drive in accordance with manufacturer's instructions.

B. Align fan and motor sheaves to allow belts to run true and straight.

C. Bolt equipment to curbs with galvanized lag bolts.

D. Install vibration control devices as shown on drawings and specified in Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.

3.2 PRE-OPERATION MAINTENANCE

A. Lubricate bearings, pulleys, belts and other moving parts with manufacturer recommended lubricants.

B. Rotate impeller by hand and check for shifting during shipment and check all bolts, collars, and other parts for tightness.

C. Clean fan interiors to remove foreign material and construction dirt and dust.

3.3 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 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. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.

B. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC and STEAM GENERATION.

D. Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.

E. Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC.

1.3 QUALITY ASSURANCE

A. Refer to Article, QUALITY ASSURANCE, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

B. Fire Safety Code: Comply with NFPA 90A.

1.4 SUBMITTALS

A. Submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.

B. Manufacturer's Literature and Data:

1. Air intake/exhaust hoods.

2. Diffusers, registers, grilles and accessories.

C. Coordination Drawings: Refer to article, SUBMITTALS, in Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

1.5 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.

B. Air Diffusion Council Test Code:

1062 GRD-2015..........Certification, Rating, and Test Manual 4th Edition

C. American Society of Civil Engineers (ASCE):

ASCE7-2017.............Minimum Design Loads for Buildings and Other Structures

D. American Society for Testing and Materials (ASTM):

A167-99 2009............Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet and Strip

B209- 2014..............Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate

E. National Fire Protection Association (NFPA):

90A-2018................Standard for the Installation of Air Conditioning and Ventilating Systems

F. Underwriters Laboratories, Inc. (UL):

181-2013................UL Standard for Safety Factory-Made Air Ducts and Connectors

PART 2 - PRODUCTS

2.1 GRAVITY INTAKE/EXHAUST VENTILATORS (ROOF MOUNTED)

A. Aluminum, ASTM B209, louvered, spun, or fabricated using panel sections with roll-formed edges, 13 mm (1/2 inch) mesh aluminum welded wire bird screen, with gravity or motorized dampers where shown, accessible interior, designed for wind velocity specified in Paragraph 3.3.

1. Spun Intake/Exhaust Ventilators: Spun aluminum structural components shall be constructed of minimum 1.3 mm (16 Gauge) marine alloy aluminum, bolted to a rigid aluminum support structure. The aluminum base shall have continuously welded curb cap corners for maximum leak protection. The spun aluminum baffle shall have a rolled bead for added strength.
2. Louvered Intake/Exhaust Hoods: Louvered hood constructed from 0.081 Gauge extruded aluminum tiers welded to a minimum 3.3 mm (8 Gauge) aluminum support structure. The aluminum hood shall be constructed of a minimum 0.064 marine alloy aluminum and provided with a layer of anti-condensate coating. The aluminum base shall have continuously welded curb cap corners for maximum leak protection.
3. Low Silhouette Intake/Exhaust Ventilator: The unit shall be of bolted and welded construction utilizing corrosion resistant fasteners. The aluminum hood shall be constructed of minimum 1.60 mm (14 Gauge) marine alloy aluminum, bolted to a minimum 3.25 mm (8 Gauge) aluminum support structure. The aluminum base shall have continuously welded curb cap corners for maximum leak protection. Birdscreen constructed of 13 mm (1/2 inch) mesh shall be mounted across the relief opening.

B. See ventilator schedule on the drawings. Sizes shown on the drawings designate throat size. Area of ventilator perimeter opening shall be not less than the throat area.

C. Dampers for Gravity Ventilators without Duct Connection: Construct damper of the same material as the ventilator and of the design to completely close opening or remain wide open. Hold damper in closed position by a brass chain and catch. Extend chains 300 mm (12 inches) below and engage catch when damper is closed.

D. See paragraph 3.3 for Intake/Exhaust exposed to high wind velocities.

E. Provide Roof Curb by unit manufacturer. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC for additional requirements.

2.2 EQUIPMENT SUPPORTS

A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

2.3 AIR OUTLETS AND INLETS

A. Materials:

1. Steel or aluminum Use aluminum air outlets and inlets for facilities located in high-humidity areas. Exhaust air registers located in combination toilets and shower stalls shall be constructed from aluminum. . 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.

c. Perforated face type: Manual adjustment for one-, two-, three-, or four-way horizontal air distribution pattern without change of air volume or pressure. Provide equalizing or control grid and opposed blade over overlapping blade damper. Perforated face diffusers for VAV systems shall have the pattern controller on the inner face, rather than in the neck and designed to discharge air horizontally at the ceiling maintaining a Coanda effect.

d. Slot diffuser/plenum:

1) Diffuser: Frame and support bars shall be constructed of heavy gauge extruded aluminum. Form slots or use adjustable pattern controllers, to provide stable, horizontal air flow pattern over a wide range of operating conditions.

2) Galvanized steel boot lined with 13 mm (1/2 inch) thick fiberglass conforming to NFPA 90A and complying with UL 181 for erosion. The internal lining shall be factory-fabricated, anti-microbial, and non-friable.

3) Provide inlet connection diameter equal to duct diameter shown on drawings or provide transition coupling if necessary. Inlet duct and plenum size shall be as recommended by the manufacturer.

4) Maximum pressure drop at design flow rate: 37 Pa (0.15-inch W.G.)

4. 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.

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.

5. 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. Linear Type: To match supply units.
6. Door Grilles: Are furnished with the doors.
7. 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. Supply Registers in Psychiatric Rooms: Supply air registers shall be security type, steel with perforated faceplate, flat surface margin, extension sleeve, opposed blade damper and back mounting flanges. Faceplate shall be 5 mm (3/16 inch) (minimum) with 5x5 mm holes on 7 mm (3/16 by 3/16-inch holes on 9/32 inch) spacing and a minimum free area of 45 percent. Wall sleeve shall be 5 mm (3/16 inch) thick (minimum).

F. Air Inlet Registers in Psychiatric Rooms: Return, exhaust, transfer and relief air registers shall be security type, steel with perforated faceplate, flat surface margin, wall sleeve, opposed blade damper and back mounting flanges. Faceplate shall be 5 mm (3/16 inch) (minimum) with 5x5 mm holes on 7 mm (3/16 by 3/16-inch holes on 9/32 inch) spacing and a minimum free area of 45 percent. Wall sleeve shall be 5 mm (3/16 inch) thick (minimum).

G. Acoustic Transfer Grille: Aluminum, suitable for partition or wall mounting.

2.4 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.

2.5 FILTER RETURN/EXHAUST GRILLE

A. Provide grille within stream 1-inch deep MERV 4 filter and removable face.

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. Stainless Steel shall be No. 4 finish.
2. Standard Type: Fixed horizontal face bars set at 30 to 45 degrees, approximately 30 mm (1-1/4 inch) margin.
3. Steel, Aluminum, or Stainless steel as scheduled.
4. Standard face connected to a mounting frame with space for a throwaway filter. Hold face closed by a locking screw. Provide retaining clips to hold filter in place. Provide fiberglass throwaway filter.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with provisions of Section 23 05 11, COMMON WORK RESULTS FOR HVAC AND STEAM GENERATION, particularly regarding coordination with other trades and work in existing buildings.

B. Protection and Cleaning: Protect equipment and materials against physical damage. Place equipment in first class operating condition or return to source of supply for repair or replacement, as determined by COR. Protect equipment during construction against entry of foreign matter to the inside and clean both inside and outside before operation and painting.

3.2 INTAKE/ EXHAUST HOODS 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 185 km/h (115 mph) or, in coastal areas, as defined in ASCE 7 Fig. 1.

3.3 TESTING, ADJUSTING AND BALANCING (TAB)

A. Refer to Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC.

3.4 OPERATING AND PERFORMANCE TESTS

A. Refer to Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

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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 used 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 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 08 00 – COMMISSIONING OF HVAC SYSTEMS: Requirements for commissioning, systems readiness checklists, and training.

E. Section 23 37 00 AIR OUTLETS AND INLETS.

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 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 independent testing laboratory complies with all the requirements of this specification.

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, 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:

1. 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):

52.2-2017..........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-1-2017.............Quality Assurance Requirements for Nuclear Facilities Applications

D. Underwriters Laboratories, Inc. (UL):

900; Revision 15 July 2015 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 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

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.

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 850-2014 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.) Maximum Recommended Change-Out Resistance (Inches w.g.)	1.0 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 INSTRUMENTATION

A. Magnehelic Differential Pressure Filter Gages: Nominal 100 mm (four inch) diameter, zero to 500 Pa (zero to two inch water gage).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.

2.5 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.

2.6 FILTER RETURN GRILLES

A. Refer to Section 23 37 00 AIR OUTLETS AND INLETS.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install supports, filters and gages in accordance with manufacturer's instructions.

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 50 11
BOILER PLANT MECHANICAL EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. Feedwater deaerator, condensate and boiler feed pumps, condensate storage tank, fuel oil pumping and heating, compressed air systems, blowoff tank, chemical treatment systems, steam vent silencer, and other equipment that supports the operation of the boilers.

B. A complete listing of common acronyms and abbreviations are included in Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

D. Section 09 91 00, PAINTING.

E. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

F. Section 22 31 11, WATER SOFTENERS.

G. Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION.

H. Section 23 05 51, NOISE AND VIBRATION CONTROL FOR BOILER PLANT.

I. Section 23 07 11, HVAC AND BOILER PLANT INSULATION.

J. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

K. Section 23 08 11, DEMONSTRATIONS AND TESTS FOR BOILER PLANT.

L. Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.

M. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM OR HVAC.

N. Section 23 21 11, BOILER PLANT PIPING SYSTEMS.

O. 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. Where conflicts occur these specifications and the VHA standard will govern.

B. American Society of Mechanical Engineers (ASME):

B16.9-2018..............Factory-Made Wrought Buttwelding FittingsB16.34-2017 Valves Flanged, Threaded and Welding End

PTC 12.3 -1997..........Performance Test Code on Deaerators

ASME Boiler and Pressure Vessel Code – BPVC Section

VIII-2019..........Rules for Construction of Pressure Vessels, Divisions 1 and 2

C. American Society for Testing and Materials (ASTM):

A53/A53M-2018...........Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

A106/A106M-2019.........Standard Specification for Seamless Carbon Steel Pipe for High Temperature Service

A234/A234M-2019.........Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service

A285/A285M-2017.........Standard Specification for Pressure Vessel Plates, Carbon Steel, Low- and Intermediate-Tensile Strength

A414/A414M-2019.........Standard Specification for Steel, Sheet, Carbon, and High-Strength, Low-Alloy for Pressure Vessels

A515/A515M-2017.........Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service

A516/A516M-2017.........Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service

D. Environmental Protection Agency (EPA):

CFR 40,264.193-2014.....Containment and Detection of Releases

E. Department of Health and Human Services, Food and Drug Administration (FDA):

CFR 21,175.300-2019.....Resinous and Polymeric Coatings

F. Society for Protective Coatings (SSPC):

SP 5-2014...............White Metal Blast Cleaning

G. Department of Veterans Affairs (VA):
PG-18-10-2016..........Physical Security and Resiliency Design Manual
VHA Boiler Plant Safety Devices Testing Manual, Fifth Edition

1.4 SUBMITTALS

A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Information and material submitted under this section shall be marked “SUBMITTED UNDER SECTION 23 50 11, BOILER PLANT MECHANICAL EQUIPMENT”, with applicable paragraph identification.

C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.

D. Feedwater Deaerator with Storage Tank and Accessories:

1. Drawings showing arrangement and overall dimensions of feedwater deaerator including storage tank. Show locations of tank-mounted devices. Show locations and sizes of pipe connections and access openings. Show design of all shell, head and nozzle welds. Show access platforms as required for all maintenance and inspection points.
2. Weight of entire assembly empty and flooded.
3. Catalog data, drawings and specification sheets showing design and construction of feedwater deaerator, storage tank, recycle pumps, water flow control valves, safety valve, overflow control valve, water level and overflow control systems, vent orifice, vacuum breaker, alarm switches and all accessories.
4. Design flow capacity, oxygen removal rate, and other performance data, and pressure and temperature limitations of feedwater deaerator, recycle pumps, water flow/level control valve and control system, safety valve, overflow control valve, vent orifice, vacuum breaker, alarm switches and all accessories, to include lockout/tagout points.
5. Catalog data on oxygen test kit.
6. Oxygen sample and chemical feed probe design.
7. Deaerator inlet pressure requirements - steam and water.

8. Packaged feedwater deaerator/feedwater pump units: Boiler feedwater pump suction and discharge pipe sizing and arrangement. Design of support framework and access platforms. Pumps shall have a minimum of 762 mm (30 inches) center to center clearance and 1800 mm (6 foot) clearance above pumps. Any one pump/motor combination shall be removable without disassembly of any other pumps or components. Provide lifting attachments as required to rig pump assemblies out of frame of the assembly.
9. Seismic Restraint Data: Seismic design of support framework for packaged system. Refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

E. Condensate Storage Tank and Accessories:
1. Drawings showing arrangement and overall dimensions of tank and supports. Show locations and sizes of all pipe connections and access openings. Access platforms as required for maintenance and inspections and operation of the equipment or parts thereof.
2. Weight of entire assembly empty and flooded.
3. Design and construction (including pressure and temperature limitations) of tank, continuous blowdown heat exchanger (if provided), control valves, water level control system, level alarm switches and all accessories, to include lockout/tagout points.
4. Performance data on control valves and continuous blowdown heat exchanger (if provided). Refer to drawings (Schedules) for requirements.
5. Interior Coating: Material specification, service limitations, instructions for application, experience record under the required service conditions.

F. Blowoff Tank and Accessories, Flash Tank:
1. Drawing showing outline dimensions, arrangement and weight of tank and accessories. Locations and sizes of all pipe connections and access openings.
2. Design and construction of tank, supports, and accessories.
3. Design and performance of blowoff tank temperature control valve.

G. Boiler Feed and Condensate Transfer Pumps:
1. Drawings with dimensions of assemblies of pumps and drivers.

2. Catalog data and specification sheets on design and construction of pumps, drivers and couplings (flexible-coupled units).
3. Motor efficiency and power factor at full load.
4. Performance curves showing discharge head, required flow plus recirculation, net positive suction head required, efficiency, driver power, impeller diameter to be furnished. Refer to drawings for requirements.
5. Pressure and temperature limitations of pump unit and accessories.
6. Size and capacity of recirculation orifice.
7. Data on variable frequency drive (VFD) units and pressure controllers (if VFD specified).

H. Condensate Return Pumps (Electrical and/or Mechanical Types) :

1. Drawings with dimensions of entire unit. Drawing shall include locations and sizes of all pipe connections.
2. Catalog data and specification sheets on design and construction of pumps, receiver and accessories.
3. Catalog cuts and schematic diagram of controls.
4. Electric pump performance curves showing discharge head, flow, net positive suction head required, efficiency, motor power and impeller diameter to be furnished. Mechanical pump performance showing discharge head, flow, required inlet head and steam pressure. Refer to drawings for requirements.
5. Pressure and temperature limitations of pump unit.

I. Fuel Oil Pumping Equipment:

1. Drawings with overall dimensions and arrangement of pumps, motors, couplings, bases, drip pans, duplex strainer, relief valves, back-pressure control valve, entire fuel oil heating system (if provided) and supports and all accessories.
2. Catalog data and specification sheets on the design and construction of pumps, motors, couplings, bases, drip pans, duplex strainer, relief valves, back pressure control valves, all valves and accessories.
3. Motor efficiency and power factor at full load.
4. Pressure and temperature limitations of pumps, duplex strainer, relief valves, back pressure control valve and all valves.
5. ASTM number and pressure rating of pipe and fittings.

6. Performance data on pumps including discharge head, flow, suction lift and motor power required at viscosity range shown. Refer to drawings for requirements.
7. Sound level test data on similar pump in similar installation. Refer to Section 23 05 51, NOISE AND VIBRATION CONTROL FOR BOILER PLANT.
8. Performance data on relief valves and back-pressure control valves.
9. Pump systems below grade or the flood plain shall be 100 percent waterproof and designed for continued operation if submerged.

J. Compressed Air System:
1. Drawing with dimensions and arrangement of air compressor, motor, air dryer, receiver and all accessories.
2. Catalog data and specification sheets on the design and construction of air receiver, compressor, after-cooler, motor, air dryer, all accessories, condensate traps. Solenoid valves and filters.
3. Performance data on compressors, after coolers, air dryer, relief valves.

K. Steam Vent Silencer (Muffler):
1. Drawings with silencer dimensions and weights, and sizes and types of pipe connections.
2. Catalog data and specification sheets on the design and construction.
3. Sound attenuation data at required flow rates.

L. Boiler Water and Deaerator Water Sample Coolers:
1. Drawings with dimensions, and sizes and location of piping connections.
2. Catalog data and specification sheets on the design and construction.
3. Pressure and temperature limitations.
4. Amount of heat exchange surface.

M. Chemical Feed Systems:
1. Drawings with dimensions of entire unit which may be field installed or factory packaged prewired/pre-piped on skid. Include locations and sizes of tanks, pumps, control panels, all pipe connections, and injection nozzles or quills at the deaerators at the boilers.
2. Catalog data and specification sheets on the design and construction of injection quills, metering pumps, storage tanks, and controls.

3. Performance data on pump including head, flow, motor power. Refer to schedules on drawings for requirements.
4. Pressure and temperature limitations of unit and accessories.
5. Information on suitability of materials of construction for chemicals to be utilized.
6. Each boiler shall have a dedicated metering pump and injection quill for each chemical. No blending of chemical treatments is allowed. Chemicals are to be supplied individually and injected individually to each boiler and to each treatment point to include boiler steam line and deaerators. Chemicals needed for chemical lay-up of the boilers such as an oxygen scavenger shall have one dedicated metering pump that can be valved to inject any boiler directly.

N. Automatic Continuous Blowdown Control System:
   1. Drawings with arrangement and dimensions of entire unit. Include locations and sizes of all pipe connections.
   2. Catalog data and specification sheets on design and construction of conductivity sensor, control valves, controller.
   3. Performance data on control valves.
   4. Pressure and temperature limitations of valves and conductivity sensor.

O. Test Data – Acceptance Tests, on-site: Four copies all specified tests.

P. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replacement parts, and troubleshooting guide:
   1. Include complete list indicating all components of the systems.
   2. Include complete diagrams of the internal wiring for each item of equipment.
   3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

Q. Completed System Readiness Checklist provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician, and dated on the date of completion, in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

R. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

1.5 AS-BUILT DOCUMENTATION

A. Submit manufacturer’s literature and data updated to include submittal review comments and any equipment substitutions.

B. Submit operation and maintenance data updated to include submittal review comments, VA approved substitutions and construction revisions shall be in electronic version on CD or DVD. All aspects of system operation and maintenance procedures, including applicable piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices shall be included. A List of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.

C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the ‘third party testing company’ requirement. Provide record drawings as follows:

  1. As-built drawings are to be provided, with a copy of them on AutoCAD provided on CD or DVD. The CAD drawings shall use multiple line layers with a separate individual layer for each system.
  2. The as-built drawings shall indicate the location and type of all lockout/tagout points for all energy sources for all equipment and pumps to include breaker location and numbers, valve tag numbers, etc. Coordinate lockout/tagout procedures and practices with local VA requirements.

D. Certification documentation shall be provided to COR 21 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and provide documentation/certification that all results of tests were within limits specified. Test results shall contain written sequence of test procedure with written test results annotated at each step along with the expected outcome or setpoint. The results shall include all readings, including but not limited to data on device (make, model and performance characteristics), normal pressures, switch ranges, trip points, amp readings, and calibration data to include equipment serial numbers or individual identifications, etc.

PART 2 - PRODUCTS

2.1 GENERAL

A. Electric motor control cabinets/enclosures including VFDs in the boiler plant shall be minimum NEMA 4 or better. The design AE shall determine at the design stage based on the environmental condition and location. This shall also be indicated on the drawings.

2.2 FEEDWATER DEAERATOR WITH STORAGE TANK AND ACCESSORIES

A. Pressurized 14 to 35 kPa (2 to 5 psig) unit designed to heat and deaerate boiler feedwater by direct contact with low pressure steam. Tray type deaerating section. Horizontal feedwater storage tank. Provide accessories including vacuum breaker, safety valve, water inlet and overflow controls and control valves, water level indicators and alarms and other devices as specified and shown.

B. Performance and Operating Characteristics:

1. Oxygen Content of Feedwater Output: 7 ppb maximum over turndown range with minimum and normal feedwater input temperatures as listed.
2. Turndown: 20/1.
3. Required Maximum Feedwater Flow Output: 88 GPM, not including recirculation. See schedules for feedwater pump performance requirements.
4. No carbon dioxide in feedwater output; maximum steam vent loss 1/2 percent of input steam at maximum load.
5. Feedwater Input Temperature: Minimum temperature is 15 degrees C (59 degrees F) and normal range is 60 to 82 degrees C (140 to 180 degrees F).
6. Water Pressure Loss Through Spray Valves: 48 kPa (7 psig) maximum.
7. Steam Pressure Loss in Unit: 6.9 kPa (1 psig) maximum.

C. Feedwater Storage Capacity to the Overflow Line: Sufficient for twenty minutes operation at maximum required feedwater output with no input water, unless shown otherwise on the drawings. Overflow line (elevation) shall be set by feedwater deaerator manufacturer so that there is no water hammer when water is at this level.

D. Construction:

1. Storage Tank and Deaerator Pressure Vessels:
   a. Conform to ASME BPVC Section VIII. Design for saturated steam at 345 kPa (50 psig) with 3.2 mm (0.125 inch) corrosion allowance.
   b. Carbon steel, ASTM A285/A285M Grade C or ASTM A516/A516M Grade 70. Weld metal strength shall approximate the strength of the base metal. All welds shall be double-vee type. No single vee welds allowed. Weld undercuts are prohibited. All welding must be constructed to allow future internal weld inspections, utilizing non-destructive-testing methods.
   c. Post Weld Heat Treatment (PWHT) to stress-relieve pressure vessel to 620 degrees C (1148 degrees F) not to exceed ASME hold-time or temperature.
   d. Provide 100 percent radiography of all longitudinal and circumferential welded seams. Test nozzle-to-shell welds by wet magnetic-particle method. Hydrostatically test final assembly at 1.3 times design pressure.
   e. Furnish completed applicable ASME Forms U-1, U-1A or U-2.
   f. Provide a sacrificial magnesium anode for cathodic protection against corrosion.
   g. Provide a vacuum breaker.
2. Trays (Tray-Type Units): Stainless steel, Type 430, no spot welds.
3. Column Packing Material (Packed-Column Units): Stainless steel.
4. Spray Valve Assemblies: Spring-loaded, guided stem, stainless steel and Monel, removable. Spring-loaded, guided stem types not required on spray-type units that operate with recycle pumps at constant flow rates through the spray valves.
5. All other parts in deaerator section exposed to undeaerated liquids or gases must be constructed of stainless steel, cupro-nickel or equivalent.

6. Provide two 300 mm (12 inches) x 406 mm (16 inches) elliptical manways in storage tank, located below the normal water level, but near the tank centerline, and away from the deaeration section or internal piping. Manway locations must allow unrestricted access to tank interior with no interference from internal equipment and piping and with easy access from outside the tank. Second manway is to facilitate the annual internal inspections. Provide permanent access platforms as required.
7. Provide access openings in deaeration section to allow inspection and replacement of trays, spray valve assemblies, column packing.
8. Support: Steel saddles or legs welded to storage tank with minimum height to provide for the net positive suction head required of the pumps selected. Coordinate location with structural design of building.
9. Nameplates: Attach to bracket projecting beyond field-applied insulation. Provide all ASME pressure vessel nameplate information as required by the Code along with information identifying the designer and manufacturer of the storage tank and the deaeration section.
10. Pipe Connections:
    a. Threaded for sizes 50 mm (2 inches) and under.
    b. Flanged, 1035 kPa (150 psig) ASME, for sizes above 50 mm (2 inches).
    c. Vortex breaker in boiler feedwater pump suction connection.
    d. Overflow Pipe:
        1) Overflow pipe inside tank terminating 150 mm (6 inches) below low-level alarm set point. Operation of overflow control system must not allow water level to fall to the level of the overflow pipe inlet.
        2) Overflow pipe sizing, based on required maximum feedwater flow output of feedwater deaerator:

Feedwater Flow Rate (kg/sec)	**Feedwater Flow Rate (klb/hr)**	**Overflow Pipe Minimum Size (mm)**	**Overflow Pipe Minimum Size (in)**
0 to 3.8	0 to 30	75	3
3.9 to 7.6	31 to 60	100	4

7.7 to 12.6	61 to 100	150	6

E. Steam Safety Valve: Mount on feedwater deaerator pressure vessel. Set pressure 103 kPa (15 psig). Capacity as shown. If not shown, minimum capacity 0.11 kg/sec (900 lb/hr). For safety valve construction requirements, refer to Section 23 21 11, BOILER PLANT PIPING SYSTEMS.

F. Oxygen and Non-Condensable Gas Venting: Straight vertical pipe extending through roof from deaeration section. Provide gate valve in vent pipe, with hole drilled in wedge. Hole size selected by feedwater deaerator manufacturer for normal venting with gate valve closed.

G. Thermometers and Pressure Gauges: Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT for construction requirements. Provide thermometers on deaeration section and on storage tank. Provide compound gauge with shut-off valve and siphon on deaerator.

H. Vacuum Breaker: Sized by deaerator manufacturer to protect unit. Bronze body construction with bronze internal trim, chemical resistant silicone seat disc and an atmospheric vent, rated for 1035 kPa (150 psig).

I. Water Sample and Chemical Feed Probes: Type 304 or 316 stainless steel, multi-ported, minimum length 300 mm (1 foot), accessible for removal from exterior of tank.

J. Dissolved Oxygen Test Kit: Provide a colorimetric-comparator type kit, utilizing Rhodazine D methodology, for use during acceptance testing and for future use by the VAMC. The kit shall include self-filling ampoules, color comparator, oxygen-resistant tubing, sampling devices, sealed glass ampoules containing reagent, carrying case, all equipment necessary for complete test. Range 0-20 ppb of dissolved oxygen.

K. Cleaning and Painting: Remove all foreign material to bare metal. Coat exterior of pressure vessel with rust-preventative primer. Refer to Section 09 91 00, PAINTING. Do not coat interior of pressure vessel.

L. Insulation: Field-applied. Refer to Section 23 07 11, HVAC AND BOILER PLANT INSULATION..

M. Seismic Design: Refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS. Design the entire assembly and anchorage to building to resist seismic forces and be fully operational after the seismic event.

N. Water Level Indicators:
   1. Gauge Glasses: Red line type, overlapping glasses if multiple glasses are utilized. Provide automatic offset-type gauge valves that stop the flow if a glass is broken. Drain cock on lower gauge valve. Gauge glass protecting rods. Gauge glass must cover the entire diameter of the tank.
   2. Magnetic Float-Flag Type Water Level Gauge:
      a. Tubular level gauge with internal float using concentric magnet with stiffening rings. Float sequentially actuates magnetic flags to indicate water level. Flags anodized black on one side, gold on the other, with internal magnet.
      b. Flags magnetically interlocked with mechanical stops to allow only 180-degree rotation.
      c. Standpipe to be Schedule 40, 304 stainless steel with side type process connections for maximum visibility of gauge.
      d. Bottom connection 100 mm (4 inch) flange with drain plug. Clearance between floor and bottom flange sufficient for removal of float.
      e. Switches for signals to be SPDT, 5-amp rating.
   3. Vertical pipe type header shall be connected to top and bottom of storage tank with tank isolation valves and valved header drain. Viewable gauges shall cover entire diameter of tank.
   4. Minimum rating 121 degrees C, 200 kPa (250 degrees F, 29 psig).

O. Low Level Alarm Switch: Float type unit with magnetically actuated switch. Locate external to tank on a vertical header with valved tank connections and valved drain. Switch elevation shall be at the tank centerline. Minimum rating 121 degrees C, 200 kPa (250 degrees F, 29 psig). Provide signals to annunciator system and computer workstation specified in Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.

P. High Level Alarm Switch and Overflow Control Switch:
   1. Conductivity probe type electronic level switches providing relay contacts for separate high-level alarm operation and overflow control valve operation completely separate from control system for

inlet water flow control valves. Overflow control valve shall automatically open when the water level rises approximately 100 mm (4 inches) above the high-water alarm level. Provide high level and overflow signals to annunciator system and computer workstation specified in Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.

2. The principle of operation shall be differential resistivity of steam and water at the operating temperatures and pressures. The system shall include electronics unit, electrodes, special cable between the electrodes and electronics unit, and electrode cover. The unit shall be designed to fail safe.
3. Electronics Unit:
   a. Each unit shall be capable for signal discrimination of two electrode channels.
   b. Each electrode and its associated circuitry shall be powered by an independent power source. Power distribution system within the electronics shall be separate for each channel with its own transformer and shall be electrically isolated from other channels.
   c. Input power 110 V, 60 Hz, single phase.
   d. All input power to each electrode shall be a low voltage, low frequency ac voltage. dc voltages are prohibited because this may cause electroplating at the electrodes.
   e. The signal discrimination and fault detection system for each electrode channel shall be independent of the other channel and any fault in the electronics circuitry of one channel shall not be transferred to the other channel.
   f. The system shall have a continuous on-line fault detection system. The following faults shall be detected: Electrode failure, contamination from dirt on electrodes, electrode open circuit failure, electrode cable short to ground, electrode cable ground sense failure, power source failure, any electronic component failure. Electronic circuitry not monitored by the fault detection system shall be provide with triple redundancy, where the circuit shall continue to operate and provide contact output with up to two component failures.

g. Faults shall be annunciated through separate NO and NC contacts.

h. The front of the unit shall have a LED display for each electrode channel indicating steam or water and status of each electrode.

i. NEMA 4 or better enclosure suitable for operating temperature of -20 to 70 degrees C (-4 to 158 degrees F), with up to 100 percent relative humidity.

4. Electrodes:

a. Suitable for 121 degrees C, 200 kPa (250 degrees F, 29 psig) minimum. Material shall be stainless steel or better, smooth length threaded only allowed on end, and corrosion resistant.

b. Electrodes without gaskets are preferred.

c. Teflon insulator media.

d. Electrodes fitted into shrouded inserts which are directly welded onto the stand-pipe. Design to minimize faulty indication due to falling condensate into the electrodes.

5. Electrode Cable:

a. Pure nickel wires for at least the first two meters at the electrode end, with pure nickel crimps. PTFE insulation capable of withstanding up to 260 degrees C (500 degrees F).

b. Continuous cables from the electrodes to the electronic unit. No junction boxes allowed.

Q. Overflow Water Control Valve and Controller: Open-shut electric or electronic actuated overflow control valve actuated by conductivity probe-type water level sensor and control system.

1. Performance: When water level reaches the overflow level as set by the feedwater deaerator manufacturer, automatically open the overflow control valve to reduce the water level. Automatically close the overflow valve when the water level has been lowered to a point 100 mm (4 inches) below the high-level alarm set point. Valve operational speed shall not exceed 30 seconds for 90-degree valve movement.

2. Controller: Automatic control shall be from the high-level alarm and overflow control switch system. Provide a manual/auto switch on the main instrument panel that indicates valve position. Communicate valve position with computer work station. Control valve shall fail

open. A limit switch on the valve actuator shall initiate alarm on control station and in computer work station when valve is open.

3. Control Valve:
   a. High performance butterfly valve, double offset design.
   b. Carbon steel 17-4PH steel valve body conforming to ASME B16.34, Class 150, lug style, 316 stainless steel nitrided disc.
   c. Self-energizing TFE seat providing bubble-tight shut off service on vacuum and low pressure and pressure sealed for high pressures. Bi-directional seating.
   d. Packing adjustable, chevron design with TFE seals.
   e. 7 kPa (1 psig) maximum pressure loss at maximum flow rate (120 percent of peak deaerator capacity if valve flow and pressure drop is not scheduled).
4. Valve Actuator:
   a. Control module shall accept direct digital control input 4-20 mA or 2-10 VDC from controller. Module to provide 4-20 mA output for feedback, terminal strip, and conduit entries for power and control wiring.
   b. Torque output range shall be appropriate for the differential pressure and pressure and temperature conditions. Duty cycle: 50 to 75 percent. Actuator to fail leaving valve in open position.
   c. Electric Motors: Totally enclosed, non-ventilated, high starting torque, reversible induction type, and Class F insulation.
   d. Electrical Characteristics: As required for the application.
   e. Thermal Overload Motor Protection: Auto reset thermal switch embedded in the motor winding to trip when the maximum winding temperature is exceeded.
   f. Resolution: 100 to 400 increments through 90-degree travel.
   g. Power Gears: Alloy steel spur gears to final stage aluminum bronze worm sector gear.
   h. Bearings: High quality alloy steel sleeve and ball bearings.
   i. Housing: NEMA 4 or better, water tight, corrosion-resistant, robust aluminum die cast.
   j. Equip with two SPDT auxiliary switches, visual position indicator, manual override handle.

k. Ambient temperature range: -35 to 66 degrees C (-31 to 150 degrees F).

R. Storage Tank Automatic Water Level Controls:

1. Separate electric or electronic actuated modulating water inlet flow control valves for normal condensate transfer water and for emergency soft water makeup. Actuated by dedicated electronic controller with input signals from water level transmitter. Manual/auto control capability.
2. Performance: Maintain a constant water level, plus or minus 25 mm (1 inch), in the feedwater deaerator storage tank by controlling the flow of condensate transfer water to the deaerator. Normal water level 200 mm (8 inches) below the overflow level. If water level falls to 100 mm (4 inches) below low water alarm setpoint, automatically operate the emergency soft water makeup valve to bring the water level to 100 mm (4 inches) above low water alarm setpoint.
3. Water Level Transmitter and Controller: Transmitter shall have programmable electronics, sealed diaphragms, direct sensing electronics, no mechanical force or torque transfer devices, external span and zero adjustment. Controller shall have proportional plus reset control, adjustable proportional band, reset rate and level set points. Provide manual-automatic control station on main instrument panel. Control station shall indicate actual water level, normal and emergency level set points and valve positions. Provide same indicating and control features on computer workstation specified in Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT. If new boiler combustion controls are furnished as part of this contract, the water level controller shall be the same make and model as the combustion controls.
4. Condensate Transfer and Soft Water Flow Control Valves and Actuators:
   a. Electric or electronic actuated, globe style.
   b. Bronze or cast-iron bodies, threaded ends for pipe sizes 50 mm (2 inches) and under rated at 1725 kPa (250 psig), ASME flanged ends for pipe sizes over 50 mm (2 inches) rated at 850 kPa (123 psig) or 1035 kPa (150 psig).

c. Replaceable Type 316 stainless steel plugs and seats. RTFE seal for bubble-tight shut off. Linear flow characteristics.
d. Flow pressure loss 35 kPa (5 psig) maximum at maximum deaerator output.
e. Electric or electronic type actuator that accepts input of 4-20 mA or 2-10 VDC signal from controller.
f. Electronic positioner with 4–20 mA dc control output feedback. Mounted integral with actuator. Digital positioner with capability to self-calibrate. Maintenance diagnostic data retained in memory. Design for 121 degrees C (250 degrees F) continuous service.

2.3 CONDENSATE STORAGE TANK AND ACCESSORIES

A. Horizontal cylindrical welded steel tank, including accessory equipment, suitable for rigging into the available space. Comply with overall dimensions and arrangement of the tank and accessories shown on contract drawings. Accessories include make-up water controls and control valves, thermometer, water level gauge, and other devices as specified.
B. Service: Receiving and storing steam condensate and make-up water. Vent the tank to the atmosphere. Contents of tank may vary in temperature from 4 to 100 degrees C (40 to 212 degrees F).
C. Construction:
   1. Construct tank and appurtenances in accordance with ASME BPVC Section VIII. Tank shall have cylindrical shell and dished heads.
   2. Material of construction shall be carbon steel ASTM A285/A285M, ASTM A414/A414M, ASTM A515/A515M, or ASTM A516/A516M.
   3. Design tank for 170 kPa (25 psig) working pressure with a minimum material thickness of 10 mm (3/8 inch). Thickness of head material at any point shall not vary more than 10 percent from the nominal thickness. If the deaerator overflow is piped to the condensate tank the condensate tank shall have a design pressure and ASME stamp pressure equal to or greater than the deaerator tank’s pressure rating.
   4. Tank joints shall be double-welded butt joints or single-welded butt joints with backing strips.

5. Provide 300 mm by 406 mm (12 inches by 16 inches) elliptical manway located as shown.
6. Provide nozzles for piping connections located as shown. Nozzles shall have threaded pipe connections for pipe sizes 50 mm (2 inches) and under, flanged connections for pipe sizes over 50 mm (2 inches). Flanged nozzles shall have 1035 kPa (150 psig) ASME flanges. Tank opening for pump suction pipes shall include vortex spoilers.
7. Furnish completed ASME Form U-1 or U-1A MANUFACTURERS' DATA REPORT FOR PRESSURE VESSELS. Hydrostatically test tank at 1-1/2 times the design pressure.
8. Horizontal tank shall be supported by steel saddles, supplied by the tank manufacturer, welded to tank and anchored to the concrete bases. Design saddles to support tank (full of water), accessories, and portions of connecting piping to first hanger.
9. Affix tank nameplate to bracket that projects beyond the field-applied tank insulation. Nameplate shall include ASME stamp and data to show compliance with design, construction and inspection requirements of the Code, and tank manufacturer information.

D. Provide overflow pipe inside tank with siphon breaker as shown.

E. Overflow and vent pipe sizing (minimums):

Boiler Plant Capacity* (kg/sec)	**Boiler Plant Capacity* (klb/hr)**	**Overflow Pipe Size (mm)**	**Overflow Pipe Size (in)**	**Vent Pipe Size (mm)**	**Vent Pipe Size (in)**
0 to 3.8	0 to 30	75	3	65	2.5
3.9 to 8.3	31 to 65	100	4	75	3
8.4 to 12.6	66 to 100	150	6	100	4
*"Boiler Plant Capacity" refers to one boiler on standby and all other boilers at high fire.					

F. Continuous Blowoff Heat Exchangers:
1. Type: U-tube bundle, no shell, liquid-to-liquid, located below lowest make-up water line of condensate storage tank.
2. Service: Receives water at boiler temperature and pressure in tubes, water at condensate storage tank temperature 15 to 93 degrees C (59 to 199 degrees F) outside of tubes.
3. Heating Surface: Refer to drawings.

4. Construction: Hard-drawn seamless copper U-tubes with cast iron or steel head bolted to mating flange which is welded to head of condensate storage tank. Design for 1380 kPa (200 psig), 182 degrees C (360 degrees F).

G. Cleaning and Painting: Remove all foreign material to bare metal from interior and exterior of tank. In preparation for interior coating, sandblast interior to white metal in accordance with SSPC SP 5. Coat exterior of tank with rust-resisting primer. Refer to Section 09 91 00, PAINTING.

H. Interior Coating: Coat entire interior surface, including nozzles, with water-resistant epoxy polymerized with amine adduct-type curing agent. Coating shall be suitable for continuous service at 100 degrees C (212 degrees F) immersed in demineralized water and exposed to steam vapor. Surface preparation, application of coating, number of coats, and curing shall comply with printed instructions of coating manufacturer. Ingredients of coating shall comply with U.S. Food and Drug Regulations as listed under Title 21, Chapter 1, Part 175.300. Coating shall be smooth, even thickness, with no voids. Holiday test at low voltage with wet sponge method and repair all holidays.

I. Insulation: Field apply insulation as specified in Section 23 07 11, HVAC AND BOILER PLANT INSULATION.

J. Water Level Indicators:

1. Gauge Glasses: Red line type, overlapping glasses if multiple glasses are utilized. Provide automatic offset-type gauge valves that stop the flow if a glass is broken. Drain cock on lower gauge valve. Gauge glass protecting rods.

2. Magnetic Float-Flag Type Water Level Gauge:

a. Tubular level gauge with internal float using concentric magnet with stiffening rings. Float sequentially actuates magnetic flags to indicate water level. Flags anodized black on one side, gold on the other, with internal magnet.

b. Flags magnetically interlocked with mechanical stops to allow only 180-degree rotation.

c. Standpipe to be Schedule 40, Type 304 stainless steel.

d. Process connections 1035 kPa (150 psig) weld neck flanges. Connections side type for maximum visibility.

e. Bottom connection 100 mm (4 inch) flange with drain plug. Clearance between floor and bottom flange sufficient for removal of float.

f. Switches for signals to be SPDT, 5-amp rating.

3. Vertical pipe type header shall be connected to top and bottom of storage tank with tank isolation valves and valved header drain. Viewable gauges shall cover entire diameter of tank.

4. Minimum rating 121 degrees C, 200 kPa (250 degrees F, 29 psig).

K. High and Low-Level Alarm Switches:

1. Low Level Alarm Switch: Integral unit consisting of float, float housing, hermetically sealed mercury switch. Locate external to tank on a vertical header with valved tank connections and valved drain. Switch elevation shall be 150 mm (6 inches) below the soft water make up level.

2. High Level Alarm Switch: Integral unit consisting of conductivity probes, probe housing. Float type not acceptable. Locate external to tank on a vertical header, along with the low-level switch, with valved tank connections and valved drain. High level alarm indication shall occur 100 mm (4 inches) below the overflow level. Probes shall be ac, not dc, stainless steel with virgin Teflon insulation.

3. Provide signals to annunciator system and computer workstation specified in Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.

4. All devices exposed to tank service conditions, including sensing devices and transmitters shall be rated for 121 degrees C, 200 kPa (250 degrees F, 29 psig) minimum.

L. Automatic Water Level Controls:

1. Separate electric or electronic type modulating water inlet flow control valves for normal soft water make-up and for emergency city water makeup. Actuated by electronic controller with input signals from water level transmitter. Manual/auto control capability.

2. Performance: Maintain a minimum water level, plus or minus 25 mm (1 inch), in the tank by controlling the flow of soft water to the tank. Soft water makeup shall be activated if water level falls to 30 percent of tank diameter plus 300 mm (12 inches). If water level

falls to 30 percent of tank diameter, automatically operate the emergency city water makeup valve to bring the water level up 150 mm (6 inches).

3. Water Level Transmitter: Programmable electronics, sealed diaphragms, direct sensing electronics, no mechanical force or torque transfer devices, external span and zero adjustment.
4. Controller: Proportional plus reset control, adjustable proportional band, reset rate and level set points. Provide manual-automatic control station on main instrument panel. Control station shall indicate actual water level, soft water and emergency city water level set points and valve positions. Provide same indicating and control features on computer workstation specified in Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT. If new boiler combustion controls are furnished as part of this contract, the water level controller and transmitter shall be the same makes and models as furnished for the combustion controls.
5. Water Flow Control Valves:
   a. Globe style, bronze or cast-iron bodies, threaded ends for pipe sizes 50 mm (2 inches) and under rated at 1725 kPa (250 psig), ASME flanged ends for pipe sizes over 50 mm (2 inches) rated at 850 kPa (123 psig) or 1035 kPa (150 psig).
   b. Replaceable Type 316 stainless steel plugs and seats. RTFE seal for bubble-tight shut off. Linear flow characteristics.
   c. Flow pressure loss 35 kPa (5 psig) maximum at maximum flow rating. Unless otherwise shown, maximum flow rate shall be equivalent to 50 percent make-up rate with plant at maximum load (2 boilers at high fire).
   d. Electric or electronic type actuator that accepts input of 4-20 mA or 2-10 VDC signal from controller.
   e. Electronic positioner with 4–20 mA dc control output feedback. Mounted integral with actuator. Digital positioner with capability to self-calibrate. Maintenance diagnostic data retained in memory. Design for 121 degrees C (250 degrees F) continuous service.

f. For valve actuators, comply with Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT and Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

2.4 BOILER BLOWOFF TANK AND ACCESSORIES

A. Type: Cylindrical welded steel tank mounted vertically. Tank shall include accessory equipment and shall be suitable for rigging into the available space. Overall dimensions and arrangement of the tank and accessories shall conform to the drawings. Tank volume shall be twice the volume of a 100 mm (4 inch) blowoff (reduction in boiler water level) from the largest boiler connected to the tank.

B. Service: Suitable for receiving, venting, storing, cooling and discharging into the drain the effluent from the boilers resulting from the intermittent operation of the boiler bottom blowoffs, boiler accessory drains, and the use of continuous blowdowns.

C. Construction:

1. Construct tank and appurtenances in accordance with ASME BPVC Section VIII. Tank shall have cylindrical shell and dished heads.
2. Material of construction shall be carbon steel ASTM A285/A285M, ASTM A414/A414M, ASTM A515/A515M or ASTM A516/A516M.
3. Design tank for 275 kPa (40 psig) working pressure; the minimum material thickness shall be 10 mm (3/8 inch). Thickness of head material at any point shall not vary more than 10 percent from the nominal thickness.
4. All tank joints shall be double-welded butt joints or single-welded butt joints with backing strips.
5. Provide 300 mm by 406 mm (12 inches by 16 inches) elliptical manhole located at the vertical centerline of the tank.
6. Provide 10 mm (3/8 inch) thick carbon steel wear plate welded to interior of tank adjacent to tangential blowoff inlet as shown.
7. Provide nozzles for piping connections and provide tangential blowoff inlet located above the normal water level. Tangential pipe for blowoff inlet shall be Schedule 80, ASTM A53/A53M or ASTM A106/A106M, seamless steel pipe with beveled end for field-welding of blowoff from boilers. All other nozzles shall have threaded pipe connections for pipe sizes 50 mm (2 inches) and under, 1035 kPa (150 psig) ASME flanged connections for pipe sizes over 50 mm (2 inches).

Nozzle sizes listed below are based on National Board of Boiler and Pressure Vessel Inspectors recommendations.

Pipe Connection Sizes, mm (inches)		
Boiler Blowoff	**Water Outlet**	**Vent**
25 (1)	25 (1)	65 (2.5)
32 (1.25)	32 (1.25)	75 (3)
40 (1.5)	40 (1.5)	100 (4)
50 (2)	50 (2)	125 (5)
65 (2.5)	65 (2.5)	150 (6)

8. Furnish completed ASME Form U-1 or U-1A MANUFACTURERS' DATA REPORT FOR PRESSURE VESSELS. Hydrostatically test tank at 1.3 times the design pressure.
9. Tank nameplate shall be affixed to bracket which projects beyond the tank insulation that will be applied in the field. Apply ASME data stamp to nameplate to show compliance with design, construction and inspection requirements of the Code.
10. Support tank by steel legs welded to shell of tank. Design saddles or legs to support tank (full of water), accessories, and portions of connecting piping to first hanger.

D. Cleaning and Painting: Remove all dirt, heavy rust, mill scale, oil, welding debris from interior and exterior of tank. Prime exterior of tank with rust-resisting paint. Refer to Section 09 91 00, PAINTING.

E. Insulation: Field apply insulation as specified in Section 23 07 11, HVAC AND BOILER PLANT INSULATION.

F. Accessories:

1. Install red line type gauge glasses with protecting rods. Provide off set type gauge valves with ball-check feature to automatically prevent flow when glass is broken. Provide drain cock on lower gauge valve. Glass shall be at least 300 mm (12 inches) long and centered at the overflow level.
2. Provide thermometer and pressure gauge. Conform to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.
3. Water Outlet Temperature Control Valve:
   a. Type: Self-contained, reverse-acting thermal bulb-operated water flow control valve.

b. Performance: Control valve shall operate automatically to control blowoff tank water outlet temperature to 60 degrees C (140 degrees F) maximum by regulating the flow of cold water which mixes with the blowoff water and reduces the temperature of the blow-off water. Provide valve designed for modulating and tight shut-off service. Valve flow rates and pressure drops shall be as shown. Temperature control range shall be adjustable, 38 to 77 degrees C (100 to 170 degrees F) minimum.

c. Service: Provide valve designed to control the flow of city water with temperature 4 to 27 degrees C (40 to 80 degrees F), and pressure up to 690 kPa (100 psig). Thermal bulb will be inserted in blowoff tank outlet pipe and will be subjected to water temperatures up to 100 degrees C (212 degrees F).

d. Construction: Cast iron or bronze valve body designed for 850 kPa (123 psig) minimum WOG. Design of valve shall permit access to internal valve parts. Thermal bulb shall be separable socket type with well.

4. Provide blowoff water outlet pipe inside tank as shown to provide a water seal. Locate a 20 mm (3/4 inch) hole in top of this pipe inside tank to act as siphon breaker.

2.5 CONDENSATE RETURN PUMP UNITS (ELECTRIC, PAD-MOUNTED)

A. Type: Factory-assembled units consisting of vented horizontal pad-mounted receiver tank, simplex or duplex motor-driven pumps as shown, interconnecting piping, motor controls, and accessories. Arrangement of pumps, tank and accessories shall be as shown or specified.

B. Service: Unit shall be designed to receive, store, and pump steam condensate having temperature as shown. Pumps and motors shall be suitable for continuous service.

C. Performance: Refer to schedules on the drawings.

D. Pumps: Centrifugal or turbine-type as shown.

1. Centrifugal Pumps: Bronze-fitted, vertical shafts, with mechanical shaft seals. Stainless steel or alloy steel shafts with bronze shaft sleeves. Pump shall be designed to allow removal of rotating elements without disturbing connecting piping or pump casing mounting. Bearings shall be grease-lubricated ball or roller type. Provide casing wearing rings.

2. Turbine-type Pumps: Shall be split-case, base-mounted, flexible-coupled, horizontal shaft, bronze fitted, with mechanical shaft seals. Pumps shall be designed to allow removal of rotating elements without disturbing connecting piping. Bearings shall be grease-lubricated ball or roller type. Provide replaceable channel rings to protect casing from wear. Shaft coupling shall be flexible type, designed for the service. Provide coupling guard bolted to base plate. Provide relief valves on pump discharge lines ahead of gate valves. Set at 690 kPa (100 psig). Pipe relief vents to receiver tank. Valve capacity shall equal or exceed pump capacity at set pressure.

E. Electric Motors: Open drip proof. Select motor sizes so that the motors are not overloaded at any point on the pump head-flow performance curve. Motor shall be designed for 40 degrees C (104 degrees F) ambient temperature.

F. Receiver Tank: Cast iron or galvanized steel, with storage capacity and height of inlet connection as shown. Provide threaded or flanged openings for all pipe connections and facilities for mounting float switches. Openings for pipe sizes above 50 mm (2 inch) must be flanged. Receivers for simplex pumps shall include all facilities required for future mounting of additional pump and controls.

G. Controls:

1. Pump Operation: Provide float switches mounted on receiver tank to start and stop water pumps in response to changes in the water level in the receiver. Float switches shall be adjustable to permit the controlled water levels to be changed. Floats and connecting rods shall be copper, stainless steel or bronze. When a duplex pump unit is used, provide an alternator and a control to automatically start the second pump, when the first pump fails in keeping the receiver water level from rising.
2. Starters: Provide combination magnetic starters with fusible disconnect switches or circuit breakers. Provide low voltage control circuits (120-volt maximum).
3. Indicating Lights: Provide red light for each pump to show that the pump is running, green lights to show power is on.

4. Manual Selector Switches: Provide "on-off-automatic" switch for each pump.
5. Electrical Wiring: Shall be enclosed in liquid-tight flexible metal conduit. Wiring shall be suitable for 93 degrees C (199 degrees F) service.
6. Control Cabinet: NEMA 250, Type 4 or better, enclosing all controls, with manual switches and indicating lights mounted on the outside of the panel. Attach to pump set with rigid steel framework unless other mounting is shown on the drawings. Mount bottom of control panel minimum of 48 inches above finish floor.

H. Accessories Required:
1. Thermometer on receiver below minimum water level. Thermometer must conform to requirements in Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.
2. Basket-type inlet strainer with bolted cover, designed for 275 kPa (40 psig), 99 degrees C (210 degrees F). Provide basket with 3.2 mm (1/8 inch) diameter perforations.
3. Water level gauge on receiver. Provide gauge cocks that automatically stop the flow of water when the glass is broken. Provide gauge glass protection rods and drain on lower gauge cock.

I. Sound and Vibration: Pump units shall conform to sound and vibration limits specified in Section 23 05 51, NOISE AND VIBRATION CONTROL FOR BOILER PLANT.

2.6 FLASH TANK

A. Type: Cylindrical welded steel tank with accessories as shown. Refer to detail on drawings.

B. Service: Suitable for receiving, venting, storing and discharging to condensate return pump the effluent discharged from steam traps on high and medium pressure steam systems.

C. Construction:
1. Conform to ASME BPVC Section VIII. Fabricate from steel sheets and plates or from steel pipe and pipe caps.
2. Materials of Construction:
   a. Steel sheets and plates: ASTM A285/A285M, ASTM A414/A414M, ASTM A515/A515M, ASTM A516/A516M.

b. Steel pipe and pipe caps: Pipe ASTM A53/A53M A-S, A53/A53M A-E, A53/A53M B-S, A53/A53M B-E. Pipe Caps ASTM A234/A234M, ASME B16.9.

3. Design tank for 850 kPa (123 psig), 178 degrees C (353 degrees F).
4. Piping Connections: Threaded half couplings for pipe sizes under 65 mm (2-1/2 inches). Flanged 1035 kPa (150 psig) ASME for pipe sizes over 50 mm (2 inches).
5. ASME Forms: Furnish U-1 or U-1A, MANUFACTURERS' DATA REPORT FOR PRESSURE VESSELS.
6. Supports: Unless shown otherwise, provide floor-mounted frame constructed with steel angles.
7. Condensate Pipe: Provide perforated Schedule 80 steel pipe inside tank as shown.

D. Cleaning and Painting: Remove all dirt, heavy rust, mill scale, oil, welding debris from interior and exterior of tank. Coat exterior with rust-resisting primer. Refer to Section 09 91 00, PAINTING.

E. Insulation: Insulate per Section 23 07 11, HVAC AND BOILER PLANT INSULATION.

2.7 FUEL OIL PUMPING EQUIPMENT (BURNER FUEL)

A. Pump and Motors (for above flood plain installation):

1. Type: Constant displacement, rotary, three-screw-type, horizontal shaft, flexible-coupled, motor-driven, base-mounted, arranged as shown.
2. Service: Pumps, motors and accessories shall be designed for continuous fuel oil service as shown on the drawings.
3. Performance: Refer to schedules on the drawings. Vendor shall submit complete data to certify that pumps offered will perform in accordance with requirements for suction lift, discharge pressure, sound level limitations and flow rate at viscosity range shown.
4. Pump Construction:
   a. Pump Casing: Cast iron or steel designed for 1035 kPa (150 psig) minimum. Casing shall have removable bolted sections to allow access to internal parts.
   b. Power Rotor: Alloy steel.
   c. Idler Rotors: Pearlitic Gray Iron.

d. Shaft Seals and Bearing: Provide mechanical seals and ball bearings as recommended by pump manufacturer for the service.
e. Internal Relief Valves: Shall not be provided.

5. Electric Motors Drives: High efficiency, open drip proof. Select motor sizes so that motors are not overloaded under all operating conditions. Motors shall be designed for 40 degrees C (104 degrees F) ambient temperature. For efficiency and power factor requirements, refer to Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION.
6. Mounting - Pumps and Motors: Mount on steel or cast-iron base plates. Align pumps and motors at the factory.
7. Shaft Couplings: Shall be all metal, grid-type, flexible design that permits parallel, angular, and axial misalignment. Coupling shall be sufficiently flexible to reduce transmission of shock loads significantly. Coupling size selection shall be based on manufacturer's recommendation for service. Provide coupling guard bolted to base plate.
8. Sound and Vibration: Each combination of pump and driver shall conform to sound and vibration limits specified in Section 23 05 51, NOISE AND VIBRATION CONTROL FOR BOILER PLANT.

B. Duplex Strainers: Provide duplex, basket-type cast iron strainers designed to allow one basket to be removed for cleaning while the other is in service. Strainer shall include diverter valve with handle that will select the strainer to be in use. Operation of the diverter valve shall not stop the flow of fluid. Basket covers shall be clamp-type. Ratio of free straining area to area of strainer pipe size shall be at least 4 to 1. Strainer baskets shall be brass or stainless steel. Provide 60 mesh basket liners for No. 2 fuel oil. Strainers on suction side of pumps shall be 345 kPa (50 psig), 93 degrees C (199 degrees F) minimum design; discharge side 1380 kPa (200 psig), 93 degrees C (199 degrees F) minimum.
C. Pressure Relief Valves (Overpressure Protection): Provide at discharge of each oil pump. Size valves to relieve the maximum pumping capability of each oil pump furnished, 965 kPa (140 psig) set pressure of the relief valves plus 25 percent accumulation. Pressure settings shall be

adjustable. Valves shall have solid ungrooved plug and shall close bubble-tight.

D. Back Pressure Control Valve (Pump Pressure Control): Valve shall operate to maintain an essentially constant pump discharge pressure as required by the burners furnished, with a set pressure as scheduled on the drawings. Pressure rise shall not exceed five percent of set pressure. Flow range shall exceed the flow of the largest oil pump in the set. Set pressure shall be adjustable plus or minus 20 percent of set pressure. Valve shall have stainless steel disc and seat, bronze body. Valve disc and seat shall be renewable. Valve shall be designed for fuel oil service as shown on the drawings.

E. Gate Valves, Globe Valves, Pipe, Pipe Fittings, Pressure Gauges, Thermometers, and Miscellaneous Piping Specialties: Refer to Section 23 21 11, BOILER PLANT PIPING SYSTEMS, and Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.

F. Arrangement (Pump Set): Pumps, motors, valves, piping and accessories shall be furnished as a factory-built unit. All items of equipment shall be mounted on a steel drip pan base with an area sufficient to extend beyond the limits of all equipment, constructed of 3.2 mm (1/8 inch) steel with 50 mm (2 inch) high vertical sides. Provide threaded 15 mm (1/2 inch) plugged opening for draining. Arrange valves and piping on rigid steel supports welded to the base. All items of equipment shall be readily accessible for operation and maintenance. Pump set shall be suitable for the space available for rigging and placement.

G. Spare Parts: Complete mechanical seal for one oil pump. Complete set of casing gaskets for one oil pump. Back pressure control valve, complete.

H. Motor Controls: Provide devices to signal computer workstation that motors are on or off.

2.8 COMPRESSED AIR SYSTEM

A. Provide complete compressed air system to serve oil burner cold start atomization (steam-atomizing oil burners) and/or pressure powered condensate pump motive air, to provide shop (cleaning and maintenance) air, and to serve controls and instruments. Compressed air systems shall include compressors, motor drives, receivers, aftercoolers, filters, air dryers and accessories as scheduled, as shown on the drawings and as specified. A minimum of two compressors shall be supplied to allow for maintenance and N+1 redundancy.

B. Compressors:
   1. Type: Reciprocating, two-stage, air-cooled, intercooled, V-belt drive.
   2. Performance: Shall be as shown on the drawings. Shall be suitable for continuous service.
   3. Construction:
      a. Lubrication: Splash type with low oil level automatic shutdown switch, or pressure type with low oil pressure automatic shutdown switch.
      b. Unloading: Provide automatic cylinder air pressure unloader to prevent compressor starting under load.
      c. Inlet Filter: Dry-type with replaceable cartridge.
      d. Cylinders: Shall be removable from crankcase.

C. Receivers: Vertical or horizontal cylindrical tanks as shown on the drawings. Construct in accordance with the ASME BPVC Section VIII with inspection under the rules of the National Board of Boiler and Pressure Vessel Inspectors. Design pressure 1035 kPa (150 psig) minimum.

D. Compressor and Receiver Accessories:
   1. Water-cooled Aftercooler: Provide one for each compressor, designed to cool the compressor output air to within 7 degrees C (10 degrees F) of the cooling water temperature. Mount on or adjacent to compressor. Provide cooling water solenoid control valve. Valve shall automatically open when compressor starts and close when compressor stops.
   2. Automatic Condensate Traps: Provide on lowest point of receiver and on aftercooler if required by type of aftercooler furnished. Size shall be suitable for compressor air delivery.
   3. Safety Valve: Provide on receiver, set pressure lower than receiver design pressure. Capacity of valve at set pressure shall be greater than maximum output of all compressors supplying receiver.
   4. Pressure Gauges: Provide on receiver and as shown. Refer to specification Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.

5. Receiver Piping Connections: Shall include air in, air out, safety valve, automatic drain, valved manual drain and valved pressure gauge.

E. Compressor Controls:
   1. Compressor Serving Oil Burner Cold Start Atomization, Oil Tank Gauges, and Flue Gas Oxygen Analyzers Only: Automatic start-stop control actuated by pressure in receiver. Pressure settings shall be adjustable.
   2. Compressors Serving Boiler Plant Controls or Instruments: Dual control enabling the manual selection of either automatic start-stop control (actuated by adjustable receiver pressure switch), or constant speed control in which the compressor runs constantly but only compresses air between predetermined adjustable receiver pressure limits.
   3. Controls shall operate on 120 volts maximum. Provide "on-off-automatic" control for each compressor.

F. Electrical Motors and V-Belt Drives: Motors shall be open drip proof designed for 40 degrees C (104 degrees F) ambient temperature. Select V-belt drives in accordance with manufacturer's recommendations for frequent start-stop service. Provide belt guard that encloses belts on all sides.

G. Vibration Isolation: Refer to specification Section 23 21 11, BOILER PLANT PIPING SYSTEMS, for isolators required in piping.

H. Air Filter: Located in compressed air line between receiver and air dryer, coalescing type, designed to remove oil, entrained water mist, and dirt from the compressed air. Provide automatic drain valve piped to nearest drain. Size unit for maximum pressure drop of 3.5 kPa (0.5 psig) at normal air flow rate. Design unit for 1035 kPa (150 psig) air pressure.

I. Spare Parts:
   1. Complete set of drive belts.
   2. Two filter cartridges for each compressor intake filter.
   3. Two filter cartridges for air dryer intake filter.

2.9 STEAM VENT SILENCER (MUFFLER)

A. Type: Residential quality designed to attenuate low and high frequency sound generated by steam vented through a globe valve from a high-pressure header.

B. Service and Performance: Shall be capable of entire maximum steam output of largest boiler in the plant with superheated steam flowing through the silencer at 100 kPa (14.7 psig), 150 degrees C (302 degrees F). Steam in header will be 99.0 to 99.5 percent quality. Venting through globe valve to silencer will cause super-heating and pressure drop to near atmospheric. Unit will be a permanent installation and will be utilized to create steam loads to allow burner adjustments and boiler tests. Pressure loss through unit shall be low. Required attenuation listed below is the insertion loss. No credit is permitted for air absorption at the outlet.

C. Minimum Attenuation:

1. 12 dB minimum at 63 Hz
2. 17 dB minimum at 125 – 250 Hz
3. 25 dB minimum at 250 – 500 Hz
4. 34 dB minimum at 500 – 8000 Hz

D. Construction: Construct unit of steel with glass fiber or metallic wool acoustical packing. Protect glass fiber acoustical material from damage in high fluid impact areas. Line entire outer shell internally with acoustical material. Provide 1035 kPa (150 psig) ANSI inlet and outlet flanges as shown on the drawings. Where flanges are not shown, provide butt weld connections.

2.10 BOILER WATER AND DEAERATOR WATER SAMPLE COOLERS

A. Type: Factory-built shell and coiled tube heat exchanger with sample in tube, cooling water in shell, designed for wall mounting.

B. Construction:

1. Shell and Head: Iron, steel or stainless-steel shell, bolted or threaded into head. Head shall have wall mounting brackets and piping connections for sample in and out and cooling water out. Minimum design pressure for shell and head, 1035 kPa (150 psig). Shell removable without disturbing piping connections.
2. Sample Coil: Shall be 6 mm (1/4 inch) outside diameter stainless steel tubing, 0.11 square meter (1.2 square feet) minimum heat

exchange surface. Minimum design for 1035 kPa (150 psig), 188 degrees C (370 degrees F). Design coil to relieve stresses due to thermal expansion.

3. Arrangement: Shall be as shown on the drawings.

2.11 CHEMICAL FEED SYSTEMS

A. System may be field installed or factory packaged prewired/pre-piped on skid equipment.

B. Each boiler shall have a dedicated metering pump and injection quill for each chemical.

C. Metering pumps shall be positive displacement diaphragm pumps with adjustable flow rate, thermoplastic construction, continuous duty, fully enclosed electric motor and drive, and relief valve. Rated pump discharge pressure shall take into consideration the pressure drop through the chemical feed lines and injection nozzles and the maximum operating pressure at the point of injection. Both stroke length and stroke frequency shall be adjustable to provide a usable control range of 10 to 100 percent of capacity. Pumps shall be capable of being set up for automatic adjustment of stroke frequency based on an external signal.

D. Chemical Tanks: 190 liter (50 gallon) capacity, polyethylene, self-supporting, 20 liter (5 gallon) graduated markings, molded fiberglass cover and liquid level switch. Each tank shall be provided with molded polyethylene containment basin of volume that can contain liquid spill from a bottom tank leak. Basin shall be one piece, seamless construction, UV stabilized (for outdoor installation), chemical and impact resistance and comply with U.S. Environmental Protection Agency regulations as listed under Title 40, Chapter 1, Part 264.193.

E. Injection quills shall be of the appropriate length and capable of introducing medium to highly corrosive chemicals into a pipeline/equipment without damage to the side port or pipe wall at the point of injection and ensure that chemicals are evenly dispersed into the center of the pipeline/equipment. The materials of construction shall be suitable for use with the chemicals to be handled. The quills shall have threaded connections and rated for pressure at the point of injection. Do not locate quills immediately upstream of steam pipe bends to preclude pipe wall erosion.

F. Controls:
   1. Feedback Control: Provide control system that automatically controls output of metering pump based on the degree of deviation of a continuously measured variable from a predetermined setpoint. Controller shall be microprocessor based or use industrial grade programmable logic controllers.
   2. Liquid Level Switch: Polypropylene housing with integrally mounted PVC air trap, receptacles for connection to metering pump, and low-level alarm. Electrical characteristics shall be suitable for load served.
   3. Conductivity Controller: Packaged monitor controller with solid-state circuiting, five percent accuracy, linear dial adjustment, built in calibration switch, on off switch and light, control function light, output to control circuit and recorder. Electrical characteristics shall be as indicated in Division 26 Electrical drawings and specifications.
   4. Water Meter: Displacement type cold water meter with sealed, tamper proof magnetic drive, impulse contact register, single pole, and double throw dry contact switch. Electrical characteristics shall be suitable for use with connected equipment.
   5. Solenoid Valves: Forged brass body globe pattern, normally open or closed as required, general purpose solenoid enclosure, and continuous duty coil. Electrical Characteristics shall be as indicated in Division 26 Electrical drawings and specifications.
   6. Timers: Electronic timers, infinitely adjustable over full range, 150 second and 5-minute range, mounted together in cabinet with hands off automatic switches and status lights. Electrical characteristics shall be suitable for connected load. Refer to Division 26 Electrical drawings and specifications for power requirements.

G. Relief Valve: Rated for maximum pump capacity, set at 1200 kPa (175 psig).

2.12 AUTOMATIC CONTINUOUS BOILER BLOWDOWN CONTROL SYSTEM

A. Type: One factory-assembled system per boiler to automatically sense boiler water conductivity and operate automatic electric-powered blowdown valve to maintain desired total dissolved solids content in boiler water. Micrometer-type adjustable manual blowdown valve piped to bypass the automatic blowdown valve and conductivity sensor.

B. Service: Design valves, sensors and piping for steam and water at 1035 kPa (150 psig), 186 degrees C (366 degrees F) minimum. Controller shall be suitable for 50 degrees C (120 degrees F) ambient and resist splashing water. Design automatic and manual blowdown valves for maximum blowdown flow rate equivalent to two percent of boiler steam output. System shall automatically maintain boiler water total dissolved solids at any set point between 1000 ppm and 4000 ppm.

C. Operation: Programmable timer cycles to intermittently operate the blowdown valve to obtain conductivity samples, and to maintain the valve open for a time period until the conductivity of the boiler water reaches the set point. Provide an automatic temperature compensating circuit.

D. Controller: Shall be microprocessor-based sealed unit mounted at the boiler.

   1. Indicators on Panel Front: One-half inch high digital display showing conductivity and indicating normal or out-of-range conditions. Valve status indicators.

   2. Membrane Keypad on Panel Front: Allows manual operation of the blowdown valve, setting of conductivity set points and alarm set points, setting of timers, calibration data input.

E. Automatic Valve Construction: Carbon steel body, Type 316 stainless steel ball and stem, TFE coated stainless steel body seal. Electric actuator with NEMA-4 or better enclosure. Rated for 1035 kPa (150 psig) minimum saturated steam.

F. Manual Valve Construction: Bronze or forged steel angle-type body, hardened stainless steel disc and seat, threaded ends, rising stem, union bonnet, graduated micrometer-type dial and pointer showing amount of valve opening. Rated for 1035 kPa (150 psig) minimum saturated steam. Furnish valve blowdown chart showing flow rate versus valve opening based on 861 kPa (125 psig) boiler pressure.

G. Provide gate valves and unions at inlet of conductivity sensor and outlet of automatic control valve so that these items can be removed from the system while maintaining the manual control valve in service. Comply with Section 23 21 11, BOILER PLANT PIPING SYSTEMS.

PART 3 - EXECUTION

3.1 INSTALLATION

A. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no additional cost or time to the Government.

B. Feedwater Deaerator with Storage Tank and Accessories, Condensate Storage Tank, Blowoff Tank, Flash Tank.

1. Coordinate location with structural requirements of the building.
2. Location shall permit access to and removal of all internal and external features without removing other items of equipment or piping.
3. Bolt to building as recommended by manufacturer or as shown. Comply with seismic requirements in Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS. Arrange anchorage to allow thermal expansion of unit.
4. Clean interior of equipment before placing in service.
5. Deaerator vent pipes must extend vertically through roof. Horizontal runs are prohibited.
6. All controls, safeties, set points, etc. must conform to the VHA Boiler Plant Safety Devices Testing Manual.

C. Boiler Feed and Condensate Transfer Pumps:

1. For base-mounted horizontal-shaft pumps, connect base drain to 20 mm (3/4 inch) pipe. Extend pipe to nearest open sight or floor drain.
2. Align pumps and drivers at the factory. At job site, a millwright shall level, shim, bolt, and grout the base plates or base frames onto the concrete pads and shall also check the alignments of flexible-coupled pumps and drivers and make corrections necessary. Check alignment when both pump and driver are at normal operating temperature.
3. Where packaged deaerator-feed pump unit is required, boiler feed pump base plates shall be welded or bolted to deaerator support frame.
4. If water-cooled bearings or quenched or flushed or water-cooled stuffing boxes are provided on pumps, contractor shall install on each pump valved 15 mm (1/2 inch) piping connections to cold water

supply, and 15 mm (1/2 inch) drains to nearest open sight drain. Provide unions at all connections to pumps.

D. Mechanical Condensate Pump: Provide sufficient elevation difference between the receiver condensate inlet and outlet and the trap inlet to assure the required head for proper functioning and capacity. Steam supply line shall include gate valve and Y-type strainer.

E. Condensate Return Pump Units (Sump Type): Provide the exterior of new receiver tanks with two heavy coats of asphalt or bituminous waterproofing compound. Mounting into the floor shall include waterproofing gaskets and grouting that will prevent ground water from entering the building from around the receiver. Unit shall be level.

F. Fuel Oil Pumping Equipment and Fuel Oil Accessories: Locate equipment to permit access to all valves and controls, and to permit removal and cleaning of heat exchanger tubes.

G. Compressed Air System: Pipe all drain connections individually to nearest floor drain. Use 15 mm (1/2 inch) piping. Provide union at each drain connection on the equipment.

H. Automatic Continuous Boiler Blowdown Control System: Locate controller on floor-supported angle at four feet above the floor at the boiler adjacent to the continuous blowdown valves. Keypad and indicator must face aisle.

3.2 TESTING AND BALANCING FEEDWATER DEAERATOR WITH STORAGE TANK AND ACCESSORIES

A. Demonstrate the ability of the deaerator to perform as specified in regard to oxygen removal and outlet temperature, over the required output flow range and input temperature range of unit. Test performance at 5 percent and 100 percent of capacity, and at two intermediate points to be selected by the COR. Repeat test two times at each load point.

B. Determine temperatures and pressures by calibrated thermometers and pressure gauges.

C. Utilize the specified colorimetric comparator type dissolved oxygen test kit. After completion of tests, clean the test kit apparatus, replace all ampoules used and parts missing or broken, and deliver the kit to the COR.

D. Various impurities in feed water can interfere with the colorimetric test. When impurities are present, the Contractor shall be prepared to test for dissolved oxygen using the titration test as described in ASME PTC 12.3. COR may permit other test methods.
E. This test shall be performed in conjunction with any boiler tests that are specified.
F. Prior to requesting final tests, pretest unit using method specified for final test. All final tests must include at the minimum the tests listed in the VHA Boiler Plant Safety Devices Testing Manual. Submit test data for review.
G. All permanent work platforms shall be in place before testing. The use of or need for step ladders to perform any inspection, test, or maintenance shall be considered a failure to install the equipment in accordance with specifications that require access to equipment. The contractor shall correct at no additional cost or time to the Government before beneficial use can start.

3.3 STARTUP AND TESTING

A. Perform tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.
B. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.
C. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the COR and Commissioning Agent. Provide a minimum notice of 10 working days prior to startup and testing.

3.4 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
B. Components provided under this section of the specification will be tested as part of a larger system.

3.5 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer’s technical representative for 8 hours to instruct each VA personnel responsible in operation and maintenance of the system.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

C. Comply with Section 23 08 11, DEMONSTRATIONS AND TESTS FOR BOILER PLANT.

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SECTION 23 51 00
BREECHINGS, CHIMNEYS, AND STACKS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies flue gas exhaust system and all accessories from the boiler outlet to the stack outlet to the atmosphere. Flue gas recirculation (FGR) ductwork (if required by burners furnished) is also specified.

B. A complete listing of common acronyms and abbreviations are included in Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION, Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

D. Section 05 50 00, METAL FABRICATIONS: Frames and supports.

E. Section 07 60 00, FLASHING AND SHEET METAL: Roof Penetrations.

F. Section 09 91 00, PAINTING.

G. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

H. Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION.

I. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

J. Section 23 05 51, NOISE AND VIBRATION CONTROL FOR BOILER PLANT.

K. Section 23 05 93, TESTING, ADJUSTING, AND BALANCKING FOR HVAC: Economizer water flows.

L. Section 23 07 11, HVAC AND BOILER PLANT INSULATION.

M. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS: Requirements for commissioning, systems readiness checklists, and training.

N. Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT: Boiler Draft Control System.

O. Section 23 52 39, FIRE-TUBE BOILERS: Economizers.

1.3 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Where conflicts occur these specifications and the VHA standard will govern.

B. American Institute of Steel Construction (AISC):

325-2017................Steel Construction Manual, 14th Edition

C. ASTM International (ASTM):

A36/A36M-2019...........Standard Specification for Carbon Structural Steel

A242/A242M-2018.........Standard Specification for High-Strength Low-Alloy Structural Steel

A307-2016...............Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 psi Tensile Strength

A563-2019...............Standard Specification for Carbon and Alloy Steel Nuts

A568/A568M-2019.........Standard Specification for Steel, Sheet, Carbon, Structural, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled

D. American Welding Society (AWS):

D1.1/D1.1M-2020.........Structural Welding Code-Steel

E. Manufacturer’s Standardization Society of the Valves and Fittings Industry (MSS):

SP-58-2018..............Pipe Hangers and Supports – Materials, Design, Manufacture, Selection, Application, and Installation

F. National Fire Protection Association (NFPA):

31-2016.................Standard for the Installation of Oil-Burning Equipment

54-2018.................National Fuel Gas Code

211-2019................Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances

G. Underwriters Laboratories (UL):

103-2010 (R2012)........Standard for Factory-Built Chimneys for Residential Type and Building Heating Appliances

441-2010 (R2016)........Standard for Gas Vents

641-2010 (R2013)........Standard for Type L Low-Temperature Venting Systems

1738-2010 (R2017).......Standard for Venting Systems for Gas-Burning Appliances, Categories II, III, and IV

1.4 SUBMITTALS

A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Information and material submitted under this section shall be marked “SUBMITTED UNDER SECTION 23 51 00, BREECHINGS, CHIMNEYS, AND STACKS”, 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. Design, materials, weights, construction, pressure and temperature limitations of breeching and stack systems, and flue gas recirculation system. Structural and Seismic design data.

E. Drawings showing all components, system arrangement and dimensions.

F. Design, construction, material specifications, allowable movements, movement forces, pressure and temperature limitations of expansion joints.

G. Damper design, construction, pressure and temperature limitations, pressure loss at design flow, and leakage of closed damper.

H. Support designs, locations and loads for entire assembly. Seismic design data.

I. Written statement from boiler/burner manufacturer that the design of the system is satisfactory to achieve the required boiler/burner performance.

J. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replacement parts, and troubleshooting guide:

1. Include complete list indicating all components of the systems.
2. Include complete diagrams of the internal wiring for each item of equipment.

3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

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 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

L. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

1.5 QUALITY ASSURANCE

A. Provide scale drawings showing nominal dimensions and weight of the systems.

B. Boiler and burner manufacturer shall review complete system from boiler flue gas outlet to stack outlet to atmosphere and advise the Government of any changes required to meet boiler and burner performance requirements. Note the altitude of plant site.

C. If a double wall, factory-fabricated, positive pressure breeching and stack system is provided, the manufacturer shall completely engineer the entire system and provide all components. Manufacturer’s representative shall provide installation instructions prior to start of construction, train the installers and certify in writing to the COR that the entire installation complies with the official standards of the manufacturer and with the project contract documents.

D. Flue gas recirculation ductwork shall be designed and provided by the burner manufacturer.

E. Conform to NFPA 54 and NFPA 31 for sizing, design of flue gas vents, and installation of fuel burning equipment and appliances.

F. Components coming in contact with the products of combustion shall carry the appropriate UL or ULC listing.

1.6 AS-BUILT DOCUMENTATION

A. Submit manufacturer’s literature and data updated to include submittal review comments and any equipment substitutions.

B. Submit operation and maintenance data updated to include submittal review comments, VA approved substitutions and construction revisions shall be in electronic version on CD or DVD inserted into a three-ring binder. All aspects of system operation and maintenance procedures, including applicable piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices shall be included. A List of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.

C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the 'third party testing company' requirement. Provide record drawings as follows:
   1. As-built drawings are to be provided, with a copy of them on AutoCAD provided on CD or DVD. The CAD drawings shall use multiple line layers with a separate individual layer for each system.

D. The as-built drawings shall indicate the location and type of all lockout/tagout points for all energy sources for all equipment and pumps to include breaker location and numbers, valve tag numbers, etc. Coordinate lockout/tagout procedures and practices with local VA requirements.

E. Certification documentation shall be provided to COR 21 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and provide documentation/certification that all results of tests were within limits specified. Test results shall contain written sequence of test procedure with written test results annotated at each step along with the expected outcome or setpoint. The results shall include all readings, including but not limited to data on device (make, model and performance characteristics), normal pressures, switch ranges, trip points, amp readings, and calibration data to include equipment serial numbers or individual identifications, etc.

PART 2 - PRODUCTS

2.1 BREECHING, STACKS, FGR DUCTWORK

A. Refer to drawings for arrangement and dimensions, except FGR ductwork shall be designed by the burner manufacturer. FGR ductwork construction, material and gauge thickness shall be the same as in the main chimney/stack. Connections to boilers and economizers must comply with the written recommendations of the boiler and economizer manufacturers. Ninety-degree tee sections are prohibited. Intersections must be made with lateral tees.

B. Service: Design for continuous 315 degrees C (600 degrees F), 12 kPa (50 inches WC) positive and negative internal pressure, for a wind-loading for outside stacks of 65 psf. Design system and supports for seismic loads in accordance with Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

C. Pre-engineered, Pre-Fabricated, Double-Wall System:

1. Complete factory-built system, all components and installation engineered and provided by manufacturer of system.
2. Provide double wall metal stacks, tested to UL 103 and UL 641, and UL-listed, for use with building heating equipment, in compliance with NFPA 211.
3. Corrosion-resistant steel, double-wall, circular cross section, positive pressure, blanket insulation between walls. For stack sections outside the building, air space with no insulation between walls is allowed.
4. Factory-built standard sections, connected in the field with joining system designed and provided by system manufacturer. Designed to be pressure and vacuum-tight, no deformation, at the service conditions specified.
5. System manufacturer’s engineered support system, attached to structural members of the building, with expansion joints between rigid supports. Thermal expansion shall be handled by expansion joints and variable spring hangers. Thermal expansion and weight of system shall not impose loads in excess of that allowed by manufacturer of boiler, economizer, or any other equipment, or

exceed capabilities of building structure. Spring hangers shall conform to MSS SP-58, Type 51, and variable spring.

6. Inner Wall: Stainless steel, Type 30420 gauge minimum thickness for diameters 900 mm (36 inches) and smaller and 1.2 mm (0.047 inches) minimum thickness for diameters greater than 900 mm (36 inches) and 1200 mm (48 inches) and less.
7. Outer Wall: Aluminized or galvanized steel except 304 stainless steel outside of building, 0.6 mm (0.024 inch) minimum thickness for inner wall diameter 800 mm (31-1/2 inches) and less, 0.89 mm (0.035 inch) minimum thickness for inner wall diameter over 800 mm (31-1/2 inches) and 1200 mm (48 inches) and less.
8. Insulation Between Walls: Fiberglass or mineral wool, 315 degrees C (600 degrees F). Minimum thickness 50 mm (2 inches).
9. Bands for Joining Sections: Same material as section being joined. Utilize sealant provided by system manufacturer.
10. Roof and wall penetrations shall be manufacturer’s standard ventilated thimble. Conform to Section 07 60 00, FLASHING AND SHEET METAL.
11. Stack Outlet: Provide as shown, double cone rain cap or other type termination designed by manufacturer of the stack system.
12. Drain Section: Provide inside building below roof to drain rain water from stack. Extend drain pipe to floor drain.
13. Guys: Provide stack guy wires above roof, with spring-loaded tensioners, in accordance with printed instructions of stack manufacturer.

2.2 EXPANSION JOINTS

A. Provide sufficient types, quantities, and locations of expansion joints to completely absorb all thermal expansion of the system without imposing excessive loads on equipment or building structure. Fabric joints shall be used on single-wall stack and breeching system. On factory-fabricated double wall stack or breeching system, use slip-type, bellows-type, or fabric expansion joints engineered by designer of the stack and breeching system.
B. Service: Design for 300 degrees C (572 degrees F), 5 kPa (20 inches WC) positive and negative internal pressure, continuous duty.

C. Construction, Fabric Joints:
   1. Fabric: High strength, designed for dewpoint service.
   2. Internal Baffles: Carbon steel with stiffeners. Designed to protect interior surfaces of fabric from wiping action of the flue gases.
   3. Welded frame, 6 mm (1/4 inch) thick ASTM A568/A568M steel with 100 mm (4 inch) minimum flange height, flat-belt design, fabricated by expansion joint manufacturer. Fabric element bolting, 10 mm (3/8 inch) diameter, 150 mm (6 inch) maximum centers.
D. Construction, Factory-Fabricated Double-Wall System Joints:
   1. Materials: Same as factory-fabricated breeching system.
   2. Packing Gland: High temperature rating. Provide seal between sliding and fixed portions of joint.

2.3 ACCESSORIES

A. Drains: Provide threaded pipe connection to allow drainage at all low points and drain connections in stack and breeching systems. Slope piping system to the drain. Pipe size shall be 25 mm (1 inch) minimum.
B. Instrument Ports: Locate on individual stack or breeching serving each boiler. Locate in non-turbulent zone within 3600 mm (12 feet) of boiler room floor between boiler and economizer (when economizer is provided) or locate accessible from platform. Provide separate ports for the following:
   1. Flue gas oxygen analyzer: Coordinate with analyzer furnished.
   2. Opacity monitor (if required): Coordinate with sensor furnished. Locate downstream from oxygen analyzer.
   3. Stack temperature sensor: Coordinate with sensor furnished.
   4. Draft gauge: 25 mm (1 inch) diameter coupling, plugged.
   5. Test instruments: 25 mm (1 inch) diameter coupling, plugged.
C. Access Doors: Bolted, gasketed, insulated, with handles. Provide where shown. Minimum opening 400 mm x 400 mm (16 inches x 16 inches).

PART 3 - EXECUTION

3.1 GENERAL

A. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no additional cost or time to the Government.

3.2 INSTALLATION – PRE-ENGINEERED, PRE-FABRICATED DOUBLE WALL SYSTEM

A. Supports: Completely support all systems from the building structure without overloading the building structure or the connected equipment. Support system shall be engineered by the system manufacturer and shall accommodate thermal expansion. Refer to seismic requirements in Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

B. Factory-Fabricated Stack or Breeching System:

   1. Install in accordance with manufacturer's printed instructions, NFPA 54 and NFPA 31.
   2. Deliver a copy of the instructions to the COR prior to commencing the installation.
   3. Representative of manufacturer shall provide field training on all installation techniques to all installers.

C. Connect 25 mm (1 inch) minimum pipes with ball valves to breeching and stack drains. Extend to floor drain.

D. Boiler or Economizer Outlet Dampers: Locate so that there is no restriction in the flow of flue gas recirculation (if provided).

E. Pitch breechings with positive slope up from fuel-fired equipment to chimney or stack.

3.3 INSTALLATION – CUSTOM-DESIGNED, FIELD-FABRICATED, STEEL SINGLE WALL SYSTEM

A. Supports: Completely support all systems from the building structure without overloading the building structure or the connected equipment. Support system shall be as shown on the drawings. Refer to seismic requirements in Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

B. Joints: Provide continuous weld between boiler outlet and connecting transition, breeching or stub stack and at connections to economizers, when recommended by manufacturer of economizer or boiler. Securely bolt all remaining joints and provide gaskets rated for service at 315 degrees C (600 degrees F).

C. Field-Applied Insulation: Refer to Section 23 07 11, HVAC AND BOILER PLANT INSULATION.

D. Connect 25 mm (1 inch) minimum pipes with ball valves to breeching and stack drains. Extend to floor drain.

E. Boiler or Economizer Outlet Dampers: Locate so that there is no restriction in the flow of flue gas recirculation (if provided).

F. Pitch breechings with positive slope up from fuel-fired equipment to chimney or stack.

G. Install in accordance with NFPA 54 and NFPA 31.

3.4 INSTALLATION OF VENT FOR CONDENSING APPLIANCES

A. Installation shall conform to manufacturer’s installation instructions.

B. Protect materials from accidental damage.

C. All supports, roof or wall penetrations, terminations, appliance connectors and drain fittings required to install the vent system shall be included.

D. Joint assembly utilizes a flange & sleeve joint connection for diameters 150 to 300 mm (6 to 24 inches). Joint assembly utilizes flanged mating surfaces for diameters 660 to 900 mm (26 to 36 inches). Manufacturer approved sealant will be used on the flange surface. Flanges are joined with a V-band secured by tightening draw bolts. Manufacturer approved sealant will be applied to the channel of the V-band prior to installation. Utilize a manufacturer approved snap-lock gasket connection for diameters 75 to 125 mm (3 to 5 inches).

E. For double wall vents, where exposed to weather, the outer closure band shall be sealed to prevent moisture from entering the space between the walls.

F. All parts exposed to the weather shall be protected by one (1) coat of corrosion and heat resistant base primer and one (1) coat of heat resistant paint unless constructed of 430, 304 or 316 stainless steel.

G. Vent shall terminate in accordance with installation instructions and local codes.

3.5 STARTUP AND TESTING

A. Perform tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.

B. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.

C. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with COR and Commissioning Agent. Provide a minimum notice of 10 working days prior to startup and testing.

3.6 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

B. Components provided under this section of the specification will be tested as part of a larger system.

3.7 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer's technical representative for 4 hours to instruct each VA personnel responsible in operation and maintenance of the system.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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SECTION 23 52 39

FIRE TUBE BOILERS

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies packaged fire tube boiler with trim (accessories), dual fuel (natural gas and No. 2 oil) burner, fuel valve and piping trains, flue gas economizer, and other accessories.

B. A complete listing of common acronyms and abbreviations are included in Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

C. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.

D. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

E. Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION.

F. Section 23 05 51, NOISE AND VIBRATION CONTROL FOR BOILER PLANT.

G. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

H. Section 23 08 11, DEMONSTRATIONS AND TESTS FOR BOILER PLANT.

I. Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.

J. Section 23 21 11, BOILER PLANT PIPING SYSTEMS.

K. Section 23 50 11, BOILER PLANT MECHANICAL EQUIPMENT.

L. Section 23 51 00, BREECHINGS, CHIMNEYS, AND STACKS.

M. 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. Where conflicts occur these specifications and the VHA standard will govern.

B. ASTM International (ASTM):

A106/A106M-2019.........Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service

A178/178M-2019..........Standard Specification for Electric-Resistance-Welded Carbon Steel and Carbon-Manganese Steel Boiler and Superheater Tubes

A254-2019...............Standard Specification for Copper-Brazed Steel Tubing

C612-2019...............Standard Specification for Mineral Fiber Block and Board Thermal Insulation

D396-2019...............Standard Specification for Fuel Oils

C. American Society of Mechanical Engineers (ASME):

B31.1-2018..............Power Piping

ASME Boiler and Pressure Vessel Code:

BPVC Section I-2019.....Rules for Construction of Power Boilers

BPVC Section II-2019 Materials

BPVC Section VII-2019 Recommended Guidelines for the Care of Power Boilers

BPVC Section VIII-2019 Rules for Construction of Pressure Vessels

BPVC Section IX-2015 Welding, Brazing, and Fusing Qualifications

Performance Test Code (PTC):

PTC 4-2013..............Fired Steam Generators

D. Environmental Protection Agency (EPA):

CFR 40, PART 60, Appendix A,

Method 9-2017...........Visual Determination of the Opacity of Emissions from Stationary Sources

E. Department of Health and Human Services, Food and Drug Administration (FDA):

CFR 21, 173.310-2016.......Boiler Water Additives

F. National Fire Protection Association (NFPA):

85-2019.................Boiler and Combustion Systems Hazards Code

G. Department of Veterans Affairs (VA):

........................VHA Boiler Plant Safety Devices Testing Manual, Fifth Edition

1.4 SUBMITTALS

A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Information and material submitted under this section shall be marked “SUBMITTED UNDER SECTION 23 52 39, FIRE TUBE BOILERS”, 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. Boiler:

1. Complete catalog information and outline drawings of boiler, burner, and accessories with dimensions including tube removal space and access door opening space.
2. Catalog cuts showing arrangement and construction of pressure parts, casing, internals, and support frame.
3. Piping connection sizes, locations, types (threaded or flanged).
4. Technical data including temperature rating and arrangement of refractory and insulation.
5. Steam nozzle construction, including the maximum forces and moments that are allowed to be imposed by connected piping.
6. Amount of heating surface and combustion volume.
7. Weight of boiler empty and flooded including burner and boiler and burner accessories, including corner weights and center of gravity dimensions for coordination with foundation design.
8. Design pressures and temperatures.
9. Recommended anchorage of boiler support frame to foundation.
10. Furnace viewport construction, locations.
11. Dimensioned location of normal water line, lowest and highest permissible water level, set points of water level alarms and cutoffs.
12. Predicted external surface temperature of front, rear and sides of boiler.
13. Seismic design data on boiler and anchorage of boiler to foundation. Refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

E. Boiler Trim: Includes bottom blowoff valves, water level alarm and cutoff devices, water level gauge, low water cutoffs, piping, all valves and fittings furnished by boiler manufacturer, feedwater control system, steam safety valves, steam pressure gauge, stack thermometer, draft gauge, and steam pressure switches.

1. Design, construction, arrangement on the boiler.
2. Pressure and temperature limitations.
3. ASTM numbers and schedule numbers of piping.
4. Type and pressure ratings of pipe fittings.
5. Flow and pressure drop data on feedwater regulating valves.
6. Technical data on water level control system.
7. Scale ranges of gauges, thermometers and pressure switches.
8. Location of water level sensing and indicating device set points in relation to normal water line and lowest and highest permissible water levels of boiler.
9. Set pressure and capacity of safety valves.

F. Burner and Fuel Valve and Piping Trains:

1. Catalog data and drawings showing burner assembly and fuel train arrangement.
2. Outline drawings of flue gas recirculation (FGR) ductwork (if applicable).
3. Outline drawings of sound attenuators on forced draft fan intake or discharge.
4. Drawings showing assembly of throat refractory into furnace.
5. Type and temperature rating of throat refractory.
6. Drawings and catalog data on all equipment in igniter (pilot) train, main fuel trains, and atomizing media train. Include data on pressure and temperature ratings, flow versus pressure drop, performance characteristics. Include complete data on air compressors (for oil atomizing) with sound attenuators and motors.
7. ASTM numbers and schedule numbers on all piping.
8. Type and pressure ratings of pipe fittings.
9. Burner flow and pressure data:
   a. Main burner fuel and atomizing air pressures and flows at maximum required firing rate.
   b. Igniter (pilot) fuel flow and burner pressure.
   c. Natural gas main fuel pressure at inlet and outlet of main burner pressure regulator.

d. Igniter (pilot) fuel pressures (natural gas and LP gas) at inlet and outlet of burner-mounted pressure regulators.
e. Forced draft fan static pressure, power, and air flow at maximum firing rate.
f. Oil pressure required at boiler fuel oil pump inlet (if applicable).

10. Full load efficiency and power factor of all motors.
11. Predicted sound level at maximum firing rate on each main fuel.
12. Weight of burner assembly.
13. Steps required to change from one fuel source to another.

G. Burner Management (Flame Safeguard Control) System: Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.

H. Flue Gas Economizer:

1. Drawings showing arrangement and dimensions of unit and all accessories.
2. Design and construction of unit and accessories including safety relief valve.
3. Weight of entire unit, empty and flooded.
4. Pressure and temperature limitations of unit and accessories.
5. Performance data on safety relief valve.
6. Manufacturer’s support requirements.

I. Seismic data. Refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

J. Boiler, Burner, Economizer Predicted Performance Data:

1. At Maximum Required Output: On each fuel at site altitude, with and without economizer (if applicable) in service, at 15 percent excess air. Data must include fuel and steam flow, boiler flue gas outlet temperature, economizer (if provided) flue gas outlet temperature, steam quality, boiler efficiency, furnace pressures, and predicted boiler radiation and unaccounted losses, feedwater and flue gas pressure losses in the economizer (if provided).
2. At low fire, 25 percent, 50 percent, and 75 percent of Maximum Required Output. Excess air, CO ppm on each fuel.

K. Schematic wiring diagram of boiler control system showing all components, all interlocks, etc. Schematic wiring diagram shall clearly identify factory wiring and field wiring and separation of the burner control system from the Burner Management (Flame Safeguard Control) system.

L. ASME “P” Forms, Manufacturer’s Data Report, on boiler and economizer construction – submit after boiler and economizer are fabricated.
M. Pretest Data - Boiler, Burner, Controls: As required by Part 3.
N. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replacement parts, and troubleshooting guide:
    1. Include complete list indicating all components of the systems.
    2. Include complete diagrams of the internal wiring for each item of equipment.
    3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.
O. Completed System Readiness Checklist provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.
P. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

1.5 QUALITY ASSURANCE

A. Coordinate all new and existing equipment and conditions. This includes, but is not limited to boiler, boiler trim, burner, fuel valve and piping trains, gas pressure regulators and available gas pressure, required fuel oil train pressures and fuel oil header back pressure regulator on house oil pump set, compressed air system for oil atomization, control systems, economizer (if provided), breeching and stacks.
B. The model and size of the proposed burner shall have been applied to at least three fire tube boilers which are similar in size, proportion, number of passes and furnace dimensions to the proposed boiler. In each of the three installations, burner performance shall have conformed to requirements specified in the paragraph, BURNER AND FUEL TRAINS, subparagraph, PERFORMANCE of this Section. Provide list of these installations, and name, address, and telephone number of person familiar with each project who will serve as a reference source.

C. Regardless of fuel input rating, the equipment, installation, and operation shall conform to NFPA 85. Where conflicts exist between NFPA 85 and this specification, this specification will govern.

1.6 AS-BUILT DOCUMENTATION

A. Submit manufacturer’s literature and data updated to include submittal review comments and any equipment substitutions.

B. Submit operation and maintenance data updated to include submittal review comments, VA approved substitutions and construction revisions shall be in electronic version on CD or DVD inserted into a three-ring binder. All aspects of system operation and maintenance procedures, including applicable piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices shall be included. A List of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.

C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and shall provide the complete set at the time of final systems certification testing. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the ‘third party testing company’ requirement. Provide record drawings as follows:

   1. As-built drawings are to be provided, with a copy of them on AutoCAD provided on CD or DVD. The CAD drawings shall use multiple line layers with a separate individual layer for each system.

D. The as-built drawings shall indicate the location and type of all lockout/tagout points for all energy sources for all equipment and pumps to include breaker location and numbers, valve tag numbers, etc. Coordinate lockout/tagout procedures and practices with local VA requirements.

E. Certification documentation shall be provided to COR 21 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and provide documentation/certification that all results of tests were within limits specified. Test results shall contain written sequence of test procedure with written test results annotated at each step along with the expected outcome or setpoint. The results shall include all readings, including but not limited to data on device (make, model and performance characteristics), normal pressures, switch ranges, trip points, amp readings, and calibration data to include equipment serial numbers or individual identifications, etc.

1.7 PROJECT CONDITIONS

A. Fuels to be Fired, Main Burner: Natural gas and No. 2 fuel oil.

B. Igniter (Pilot) Fuels: Natural Gas and LP gas (propane).

C. Natural Gas: High heating value is reported as 1000 Btu/cubic foot) at gas company base pressure and temperature. Pressure provided to the inlet of the boiler-mounted regulators will be 10 psi gauge as maintained by main regulator station.

D. Fuel Oil: Will be furnished under Government contract. House pumping system is designed to provide 120 psi gauge nominal to the fuel train entrance on each burner. Pressure will vary in accordance with characteristics of backpressure regulator on oil pump set (Refer to Section 23 50 11, BOILER PLANT MECHANICAL EQUIPMENT. Oil grade (No. 2) refers to ASTM D396. No burner-mounted pump or relief valve is required.

E. Oil Atomizing Media: Low-pressure air atomizing burners are required. Atomizing air will be provided by a new plant compressed air system dedicated for atomizing air service only. This new compressed air system shall include N+1 compressors and drives and be sized to provide adequate compressed air to fire two (2) of the largest burners at 100% capacity. The burner manufacturer shall size the compressor to match the burner requirements.

F. LP Gas: Propane furnished directly to the Government for igniter (pilot) fuel by a local supplier. Regulators at tank area will be set at 34 kPa (5 psig) gauge. Serves as igniter fuel when there is an interruption to the natural gas supply.

PART 2 - PRODUCTS

2.1 BOILER

A. Type: Factory-assembled packaged Scotch marine horizontal fire tube high pressure industrial steam boiler. Four pass wetback design with internal furnace located below center of boiler shell. Designed for natural gas and No. 2 fuel oil firing.

B. Service: Continuous long-term generation of steam throughout the burner firing range in conformance to the specified performance requirements with feedwater supply at 100 degrees C (212 degrees F).

C. Performance:

1. Steam Output Quantity and Pressure: Refer to schedules on drawings.
2. Steam Output Quality: 99 percent minimum at all steam flow rates. Based on water quality in boiler of 3200 ppm maximum total solids, 15 ppm maximum suspended solids, 600 ppm maximum alkalinity.
3. Minimum Efficiency at Required Maximum Output:
   a. Natural Gas Fuel (37.3 MJ/cubic meter) (1000 Btu/cubic foot): 82.9 percent at 15 percent excess air.
   b. Fuel Oil (ASTM D396, Grade 2): 86.1 percent at 15 percent excess air.

D. Heating Surface: Heating surface is defined as the fireside area of the furnace and combustion chamber plus inside (gas side) circumferential area of all convection tubes. Minimum heating surface (5.112 square feet per boiler horsepower for a 500 HP Boiler).

E. Design Pressure: Shall equal the ASME-stamped maximum allowable working pressure of 1380 kPa (200 psig). Purpose of high design pressure is to provide additional corrosion allowance and additional safety margin to perform safety device testing.

F. Construction:

1. Codes: Comply with ASME BPVC Section I, ASME BPVC Section II, ASME BPVC Section VII, and ASME BPVC Section IX.
2. Tubes: ASTM A178/178M, Grade A, smooth wall inside and outside. Minimum thickness 2.7 mm (0.106 inches). Flue gas spinners or turbulators are prohibited.

3. The method by which the tubes are joined to the boiler tube sheet shall be the Prosser, Expand Roll and Bead method.
4. Manway: Cover and yokes shall be forged steel. Manway shall seal tight with no leakage. Provide non-asbestos gaskets.
5. Handholes: Covers and yokes shall be forged steel or cast iron. Handholes shall seal tight with no leakage. Provide non-asbestos gaskets.
6. Access to Tubes and Furnace: Provide hinged and davited doors and access panels to permit access to all tubes, burner head, and furnace for cleaning, repairs and replacement. Doors wider than the radius of the boiler shell shall be davited and shall be operable by one person. Hinges or davits are not required for access panels less than 600 mm (2 feet) in width and height. All doors and panels shall have non-asbestos gaskets and shall be sealed tight with a stud welded to the shell and a nut to secure the door. Panels shall have handles.
7. Shell Piping Connections: Flanged, bottom blow down and feedwater connections shall be flanged. Connections shall include, but not be limited to:
   a. Steam nozzle shall be 2070 kPa (300 psig) ASME flanged. Design nozzle and shell assembly to withstand forces and moments imposed by connected piping. Studding nozzle is prohibited.
   b. Locate manual steam vent on top of boiler shell to permit access to vent gate valve from platform located above boiler.
   c. Locate safety valve outlets to permit straight run of vents through roof and to permit valve handle access from platform located above boiler.
   d. Connections for water level control, alarm and indication devices.
   e. Connections for boiler feed water, chemical admission, combined continuous blowdown and water sampling. Locate below normal water level and as shown.
   f. Bottom blowoffs. Locate to permit complete collection of sediment and complete drainage.
   g. Pressure gauge and pressure switch connections. (May be connected to water level controller steam piping.)

8. Support System: Provide proper support of all elements of the boiler, burner, and accessories during shipment, rigging, and in final installation. Arrange supports to permit thermal expansion and to resist seismic shocks (in seismic areas). No element of the boiler or accessories shall be overstressed, displaced, have cracks, broken welds, or excessive deflection. All vertical elements of the boiler and accessories shall be plumb, and all horizontal elements shall be level.
   a. Base Frame: Design for mounting on flat concrete base. All elements shall be level. Provide attachments for anchorage to the concrete foundation.
   b. Rigging and Jacking: Provide lifting lugs and provisions for jacking. Painted stencils shall identify jacking locations.
   c. Platform Support Brackets: Manway access from catwalk shall be supported from roof structure, not the boiler. Provide field-installed valve and manway access catwalk alongside top of boiler.
9. Refractory and Insulation: Boiler manufacturer's standard and experience proven design except insulation on the boiler shell shall be a minimum of 50 mm (2 inches) thick. No part of the external casing shall exceed 16 degrees C (60 degrees F) above ambient, except for areas within 300 mm (1 foot) of the casing penetrations.
10. Casing: Sheet steel covering all areas of boiler shell. Flash or seal all openings at top of boiler at piping and flue connections to prevent leakage of water into insulation. Provide a 300 mm (1 foot) minimum width section of heavy gauge reinforced casing or heavy density insulation minimum 96 kg per cubic meter (6 pounds per cubic foot) along the top centerline of the entire length of the boiler to permit walking on top of the boiler without denting the casing.
11. Observation Port: Provide single port at rear of furnace located to permit flame observation. Furnish with one clear and one tinted interchangeable heat resisting glass, gas-tight operable metal closure between furnace and glass, forced air cooling to reduce moisture condensation on glass.

G. Factory Inspection and Certification: Inspect the completed boiler assembly in accordance with the requirements of the ASME BPVC Section I. The boiler inspection shall be certified. Submit four copies of ASME Form P-2 for each boiler.

H. Finish: Provide surface preparation, heat-resistant prime and two finish coats using standard color of the boiler manufacturer.

I. Controls and Safety Devices: In accordance with NFPA 85.

2.2 BOILER TRIM (ACCESSORIES)

A. Conform to ASME BPVC Section I.

B. Steam Safety Valves:

1. Capacities certified by National Board of Boiler and Pressure Vessel Inspectors (NBBI).
2. Type: Bronze or cast-iron bodies, side outlet, flanged or threaded inlet and outlet, lifting lever, dual control rings, stainless steel trim, O-ring EPDM seats on bronze valves.
3. Settings and Adjustments: Factory set, sealed, and stamped on nameplate. Set pressures as shown. Set pressure of lowest pressure valve shall not exceed normal boiler plant operating pressure by more than 207 kPa (30 psig). Provide 34 kPa (5 psig) difference in setting between each of the valves.

C. Steam Pressure Gauge:

1. Case: Turret-style, bottom connection, threaded ring, blowout disc in rear.
2. Dial: 200 mm (8 inch) minimum diameter, non-corrosive, black markings on white background.
3. Measuring Element: Bourdon tube designed for steam service.
4. Movement: Stainless steel, rotary.
5. Pointer: Micrometer adjustable, black color.
6. Window: Laminated safety glass, or plastic.
7. Accuracy: One half percent of the full span.
8. Range: 0 - 300 psig gauge.
9. Installation: Stop valve, steel piping, valved blowdown, siphon, union at gauge, and valved connection for inspector's gauge, provide valved calibration port. Refer to Detail, FIRE TUBE BOILER.

D. Water Level Safety and Operating Controls and Indicators:

1. Provide high and low water warning alarms, primary and auxiliary low water burner cutoffs, auxiliary connections with valves for connecting a differential pressure type water level transmitter, and gauge glass.
    a. High and low water warning alarms shall operate bell and separate high and low water level indicating lights on boiler control panel and shall not shut down the burner.
    b. Primary and auxiliary low water burner cutoff devices shall be in two separate water columns, piped individually to the boiler water spaces. One device shall be float-type, the other device shall be conductivity probes. Primary and auxiliary cutoffs shall require separate manual reset. Non-latching shunt switches shall allow blowdown of water columns without shutting down the burner.
    c. Water level set points for all devices shall be as recommended by boiler manufacturer.
    d. Water level control system shall maintain the water level within limits established by boiler manufacturer for normal water level with no tripping of high and low-level alarms with instantaneous load swings of 25 percent of boiler capacity. Feedwater pump will operate continuously.
    e. Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT for detailed operation of all indication, monitoring, alarm and control devices.
2. Water Column Unit with Water Level Controller, Gauge Glass, Water Level Sensor for Primary Low Water Cutoff:
    a. Float type NOT acceptable, shall use differential pressure transmitter. Primary electric probe, secondary mechanical float. low water cutoff.
    b. Height of water column and gauge glass shall be sufficient to show water level in the gauge glass at least 15 mm (1/2 inches) above high water alarm set point and at least 15 mm (1/2 inches) below auxiliary low water cutoff set point.
    c. Control system shall automatically modulate an electric feedwater flow control valve. Feedwater pump will operate continuously.

d. Gauge Glass and Gauge Valves: vertical transparent flat gauge glass rated 2620 psig at 750 degrees F. Provide automatic off-set gauge valves with ball checks to prevent fluid flow if gauge breaks. Basis of Design manufacturer: John C. Ernst Company or Clark Reliance.

3. Auxiliary Water Column with Water Level Sensors for High and Low-Level Alarms and Auxiliary Low Water Cutoff:
   a. Float type high and low-level alarm sensors and auxiliary low water cutoff sensor.
   b. UL listed, factory-built probe and chamber unit mounted externally from the boiler.
   c. Stainless steel conductivity probes and grounding probe. Virgin Teflon insulation. Basis of Design Manufacturer: Warrick Controls.
4. Water columns shall be rated for 1380 kPa (200 psig) minimum saturated steam and have boiler and drain connections.
5. Water Column Piping to Boiler and to Drains: ASTM A106/A106M, Grade B, seamless or ERW piping, Schedule 80 threaded. Fittings shall be 300 lb. malleable iron or forged steel. All changes in direction shall be with crosses, no ells. Provide valved drain piping connected to the lowest part of each of the water columns.
6. Electrical: Provide circuit breakers, transformers, all devices for complete control system. All control electronics and relays shall be in waterproof NEMA 4 panels.
7. Modulating Feedwater Control Valve:
   a. Characterized sliding gate valve. Operated by electric drive unit actuator with top mount integrated digital positioner. Equal-percent valve flow characteristics. Modified linear valve flow characteristics shall be utilized when digital positioner is furnished. Rotary actuators are not acceptable.
   b. Performance: Refer to schedules on the drawings for pressure, temperature and flow requirements. If not shown on the drawings, the valve shall be designed for maximum flow rate of 125 percent of the maximum boiler steam output with 69 kPa (10 psig) pressure drop, maximum inlet pressure of 2070 kPa (300 psig), maximum

temperature of 138 degrees C (280 degrees F). Shut-off seat leakage less than 0.0001 percent of valve CV.

c. Sliding Gate Valve: Stainless steel body, head section, actuator springs valve stem and fixed disc. Tribaloy (STN2) self-aligning sliding disc. Carbon filled PTFE packing. Minimum ratings 2070 kPa (300 psig), 138 degrees C (280 degrees F). Basis of Design manufacturer: Schubert & Salzer Model GS3 series valve with 8038 electric actuators.

d. Sound Levels: Conform to Section 23 05 51, NOISE AND VIBRATION CONTROL FOR BOILER PLANT.

8. Shunt Switches for Primary Low Water Cutoff and Auxiliary Low Water Cutoff: Provide separate non-latching shunt switches for each of the low water cutouts to allow manual blowdown of water column without tripping burner. Locate each switch adjacent to the drain valve for the low water cutout that is affected by the switch.

9. Low Water Cutout Operation: Manual reset of primary low water cutoff shall be combined with the burner management manual reset. The burner management system annunciator and associated alarm horn shall indicate the primary and auxiliary low water cutoff operation. The manual resets for primary and auxiliary low water cutoffs shall be separate, such that an operator would be alerted to a failure of the primary cutoff.

E. Stack Thermometer:

1. Dial-type, bi-metal element, stainless steel case and stem, adjustable angle, one percent of full scale accuracy, dual scale, 100 to 550 °C and 200 to 1000 °F, minimum diameter 125 mm (5 inches).

2. Electronic temperature sensor with stainless steel sheath, for indication at the BAS.

F. High Steam Pressure Burner Cutouts:

1. Provide two UL listed, FM approved units with different set points. Unit with lowest set point shall be automatic reset; unit with highest set point shall be manual reset.

2. Bellows actuated sealed snap-acting switch with adjustable set point and adjustable differential pressure (automatic reset unit); switch position indicator.

3. Rated for 1380 kPa (200 psig) minimum emergency pressure.

4. Set pressure range: To 150 percent of required set pressure.
5. Provide indicators with graduated scales for set point and differential pressure.
6. Mounting: Connect to water column piping. There shall be no valves between cutoff and boiler shell. Provide siphons at each switch to protect bellows from high temperature.
7. Set Points:
   a. Automatic Reset Unit: Refer to boiler schedule shown on the drawings. If not shown, set at 34 kPa (5 psig) below the set pressure of the manual reset unit.
   b. Manual Reset Unit: 34 kPa (5 psig) below lowest safety valve set pressure. Subtractive differential not to exceed 69 kPa (10 psig).
8. Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT for the operation of the cutouts.

2.3 BURNER AND FUEL TRAINS

A. Prototype Burners shall NOT be accepted. Burner must be an engineered design from manufacturer without alteration prior to installation on boilers, meeting 10:1 turndown. Shall meet 10:1 turndown OUT OF THE BOX.

B. Burner Type: Integral combination natural gas and fuel oil, packaged, forced draft, modulating firing and variable speed forced draft fan. Heavy-Duty, 3/16" steel construction with central lifting lug, baffles for balanced airflow distribution from the forced draft fan and necessary supports for auxiliary components. A plugged pipe coupling shall be installed on the body for pressure gauge connection, and other connections as required. The body houses a venture profile parallel flow type register. Burners without a register are not acceptable. Basis of Design manufacturer: Faber Burner Company
   1. The register shall be furnished with a centrally located gas manifold designed specifically for the conditions and pressure of the natural gas. The gas manifold shall be equipped with no more than three removable high temperature stainless steel gas spuds.
   2. Gun type with three (3) spuds, ring manifolds are not acceptable.
   3. Oil Burner: The register shall be equipped with a low-pressure air atomized type oil gun. The oil gun shall be a two-piece body &

connector system that allows for easy oil gun removal for cleaning and inspection. Burners with oil guns that require <u>any</u> hand tool for removal of oil gun will not be acceptable. The oil gun's burner body shall be equipped with cleanout valve to manually purge oil from the gun. The oil gun should slide into an air-cooled jacket tube.

4. Igniter (Pilot): Interrupted, electrically ignited, natural gas and propane. The register shall be fitted with a post-mix type gas-electric ignition system designed to produce a stable ignition flame when supplied with natural gas, or propane, at the pressure recommended by the burner manufacturer. The Ignitor assembly shall be readily accessible and removable at the burner front. An ignition transformer rated at 10,000 volts AC shall energize the Ignition system. Gas shall be supplied to ignitor by a flexible 321 stainless steel hose.
5. Register: The register shall be supplied with a stainless-steel diffuser that connects to the furnace end of the jacket tube. The diffuser can be removed by loosening a series of setscrews.
6. Register accessories: The register shall be equipped with (2) two 2 1/2" Observation Ports with sight glass. The register shall also be equipped with a scanner ball and swivel assembly to allow for proper positioning of the flame scanner.
7. Change of fuels will not require any disassembly and reassembly of the fuel train on burner fuel nozzles.
8. Removal of oil gun for cleaning will not require any hand tools.

C. Service:

1. Continuous operation at all firing rates on each fuel listed under paragraph, PROJECT CONDITIONS of this Section. Design the entire burner and fuel train system for application to the specific boiler furnished and for service at the available fuel pressures.
2. Igniter (Pilot) Fuels: Normal fuel will be natural gas. Propane will be used if there is an interruption in natural gas service.
3. Main Fuels: After boilers are accepted for operation, choice of fuels will be based on cost and availability.

D. Performance:
   1. Igniter (pilot) flame on natural gas and propane shall form close to the point of ignition and shall be stable. Ignite both the gas and oil burner with single igniter.
   2. Main flame on gas and oil fuels shall ignite at lowest firing rate.
   3. Main flame characteristics at all firing rates:
      a. Flame retained at the burner.
      b. Flame stable with no blowoff from the burner or flashback into the burner. Pulsations, rumble, or vibrations are prohibited at any firing rate.
      c. No deposits of unburned fuel or carbon at any location.
      d. No carryover of flame beyond the end of the first pass (furnace tube).
      e. Steady constant direct contact or impingement of the flame on any surface is prohibited.
   4. Main Burner Operation:
      a. Minimum turndown 10:1 on natural gas and 8:1 with #2 fuel oil.
      b. Operate at all loads on any one fuel without any manual changes to burners, fuel trains or fuel pressures, atomizing media trains or pressures.
      c. Excess Air in Flue Gases with Oxygen Trim at Null Position:

Boiler Steam Output, Percent of Maximum Required Capacity	**Percent Excess Air Allowable Range**
Below 25	15 minimum
25 to 39	15 to 23
40 to 100	15 to 23

      d. Performance at any load point shall be repeatable after increasing or decreasing the firing rate. Repeatability plus or minus five percent excess air, at 25 percent and higher boiler loading except excess air must remain within ranges specified above.
      e. Oxygen trim control set at maximum position shall not blow out the fire at any load point. At minimum position, the combustion shall not go below stoichiometric.

f. Noise and Vibration: Refer to Section 23 05 51, NOISE AND VIBRATION CONTROL FOR BOILER PLANT for requirements on forced draft fan and oil atomization system. Burners shall operate without pulsation.

5. Flue Gas Emissions Limits:
   a. Carbon Monoxide: Shall not exceed 200 ppm.
   b. Smoke: On natural gas and No. 2 oil shall not be visible and shall not exceed No. 1 on the Bacharach smoke scale.

E. Construction:
1. Burner Access (Main Burner and Igniter): Arrange fuel valve and piping trains, controls and other devices so that they do not interfere with the removal and replacement of burner parts.
2. Arrangement of Fuel Valve and Piping Trains: All devices shall be accessible for maintenance or replacement without removal of other devices. Do not attach any piping or devices to boiler casings.
3. Coatings: Provide surface preparation, heat resistant prime and two finish coats using standard color of boiler manufacturer.
4. Combustion Air System and Flue Gas Recirculation (FGR) System (if provided):
   a. Air flow rates controlled by forced draft fan inlet dampers and variable speed drive.
   b. Symmetrical, balanced distribution of combustion air into the burner.
   c. Provide induced type FGR system if FGR is necessary to achieve specified NOx limits. All FGR ductwork shall comply with Section 23 51 00, BREECHINGS, CHIMNEYS, AND STACKS.
   d. Forced Draft Fan: Airfoil or backwardly inclined wheel, electric motor driven. Design for required excess air and for static pressure that is based on losses from fan inlet to stack or chimney outlet, including economizer (if provided), at jobsite altitude. Fan shall have no resonant frequencies at all operating speeds.
   e. Motor: TEFC or open drip proof, non-overloading under all fan operating conditions, design for 40 degrees C (104 degrees F) ambient, premium efficiency type. Motors for variable speed

service shall be rated inverter-ready. Refer to Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION.

f. Damper: Design to provide accurate control of excess air with minimum hysteresis. On variable speed systems, the damper shall operate across all firing rates.

g. Motor Starter Panel: Provide motor starter and variable speed drive mounted in NEMA 4 enclosure, readily accessible. Refer to Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION. Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT, for burner management system motor power interlocks.

h. Sound Attenuators: Provide attenuators on forced draft air intakes to reduce sound levels to allowable limits. Refer to Section 23 05 51, NOISE AND VIBRATION CONTROL FOR BOILER PLANT.

5. Provide two (2) front viewports, with one clear and one tinted replaceable interchangeable glass. Locate to permit view of main and igniter flames.

6. Burner Throat: Refractory tile, shaped to promote proper combustion, arranged with provisions for expansion and contraction and rated by the refractory manufacturer for the maximum service conditions.

7. Electrical Conduit: Provide liquid-tight flexible metal conduit with sealing fittings for all power and control services to fuel trains and burners. Flexible metal conduit must be limited to 900 mm (3 feet) in length, unless additional length is required for door or burner swing. Refer to Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS.

8. Factory Testing: Mount burner and controls on boiler at factory and fire-test to verify proper operation, including Flame Safeguard and safety interlock operation.

F. Natural Gas Main Fuel Train:

1. Arrangement: Comply with typical arrangement in NFPA 85, Annex A, as modified by the following description. Starting at the entrance to the train, the devices are, in sequence: plug valve, filter, pressure gauge, pressure regulator, valved connection to pilot burner fuel train, flow meter (if required), pressure gauge, low pressure switch, two automatic safety shut off valves, valved leak

test, high pressure switch, fuel flow control valve, plug valve, pressure gauge, burner. Provide tee connection for vent between the automatic safety shut off valves. Vent line shall include valved leak test connection, automatic vent valve, valved leak test connection, lockable plug valve, vent thru roof. High and low pressure switches shall be located to sense the constant pressure controlled by the burner pressure regulator and not the variable burner pressure.

2. Filter: Replaceable fiberglass or cellulose cartridge, 10 micron or smaller particle retention. Static pressure capability two times the maximum lock-up pressure of nearest upstream pressure regulator. Maximum pressure loss at high fire 1.3 kPa (5 inches WG). Provide vent with cock for relieving pressure in filter.
3. Pressure Regulator:
   a. Single seated, diaphragm-operated, designed for natural gas service. Controlled pressure shall be sensed downstream of main valve. Valve shall pilot-operated with a 40:1 turn down rating.
   b. Service: Provide precisely controlled downstream pressure in fuel train, as required by burner and fuel trains furnished, with upstream pressure as shown or specified. Inlet and outlet emergency pressure rating shall be at least twice the lock-up pressure of the nearest upstream pressure regulator.
   c. Performance: Maximum outlet pressure droop 5 percent of the set pressure over the burner firing range. Maximum lock-up pressure 1.5 times regulated pressure. Speed of response to opening of automatic safety shut off valves shall be sufficient to allow set pressure of low pressure switch to be within 20 percent of the normal operating pressure with no nuisance burner trips.
   d. Construction, Main Valve: Cast iron body, replaceable plug and seat. Downstream pressure-sensing line.
4. Automatic Safety Shut-Off Valves:
   a. Type: Motorized-opening, spring closing, controlled by burner control system. Two valves required. Acceptable manufacturer: Maxon.
   b. Service: Provide open-shut control of fuel flow to burner. Valves shall shut bubble tight and be suitable for operation with

upstream pressure of two times the highest pressure at entrance to boiler-mounted regulators.

c. Performance: Timed opening of six seconds or less to safely and smoothly ignite main flame, and close within one second.
d. Construction: Valves 65 mm (2-1/2 inches) and greater, flanged ends; valves 50 mm (2 inches) and less threaded ends; position indicator showing open and shut, visible from front or side of boiler. Aluminum seating surfaces are prohibited. Closed position interlock switch on each valve. Valved leak test fittings before and after each valve.
e. Approval: FM approved, UL listed for burner service.
f. Proof of Closure Test: Provide non-latching push button controls in the proof of closure circuit to interrupt the circuit when the valves are closed.

5. Automatic Vent Valve:
   a. Type: Motorized or solenoid closing, spring opening, full port, controlled by burner control system. Acceptable manufacturer: Maxon.
   b. Service: Provide open-shut control of vent line that is connected between the two safety shut-off valves. Valves shall shut bubble-tight and be suitable for operation with upstream pressure of two times the highest pressure at entrance to boiler-mounted regulators. Valve shall be open whenever safety shut-off valves are closed.
   c. Approval: UL listed for burner service.
6. Vent System Manual Plug Valve for Leak Tests: Located on vent line on outlet side of automatic vent valve. Provide locking device and lock wrench to lock valve to open position. Provide cylinder padlock keyed to VA Engineering key. Provide valved leak test connections between automatic vent valve and plug valve and ahead of the automatic vent valve.
7. Pressure Switches: Refer to paragraph, BURNER MANAGEMENT (FLAME SAFEGUARD CONTROL) SYSTEM WITH SAFETY INTERLOCKS AND ACCESSORIES in Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT. Switch settings must be within 20 percent of the controlled

pressure. High pressure switches shall have lockable service isolating valves and valved connections for pressurizing the switches and testing the set and trip points.

8. Fuel Flow Control Valve:
   a. Type Characterized sliding gate valve controlled by combustion control system. Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT. Control fuel flow in exact proportion to combustion airflow over the entire firing range of the burner. Static pressure rating shall exceed the lockup pressure of the boiler-mounted regulator.
   b. . Operated by electric drive unit actuator with top mount integrated digital positioner. Equal-percent valve flow characteristics. Modified linear valve flow characteristics shall be utilized when digital positioner is furnished. Rotary valves or actuators are not acceptable.
   c. Performance: Determined by burner manufacturer.
   d. Sliding Gate Valve: Stainless steel body, head section, actuator springs valve stem and fixed disc. Tribaloy (STN2) self-aligning sliding disc. Carbon filled PTFE packing. Minimum ratings 150 psig @ 280 degrees F. Basis of Design manufacturer: Schubert & Salzer Model GS3 series valve with 8038 electric actuator.
   e. Sound Levels: Conform to Section 23 05 51, NOISE AND VIBRATION CONTROL FOR BOILER PLANT.
   f. Performance and Service: Control fuel flow in exact proportion to combustion airflow over the entire firing range of the burner. Static pressure rating shall exceed the lockup pressure of the boiler-mounted regulator.
   g. Gas valve turn down capability: minimum of 30:1.
9. Pressure Gauges, Flow Meter: Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.

G. Fuel Oil Train:
   1. Arrangement: Comply with typical arrangement in NFPA 85, Annex A, as modified by the following description. Starting at the entrance to the train, the devices are, in order: manual shut off valve, filter, pressure gauge, pressure regulator (if required by burner furnished), low pressure switch, high pressure switch, 30 micron

spin on fuel filter, flow meter (if specified), oil flow control valve, valved drain, automatic safety shut off valve, valved leak test, automatic safety shut off valve, valved leak test, manual shut off valve, pressure gauge, burner. Provide retractable nozzle with flexible hoses.

2. Filter Spin on: Replaceable type, 30 Micron rating, 1500 Psig emergency rating.
3. Pressure Regulator: Do not provide unless required by the burner furnished. Pressure control is provided by a back pressure control valve on the house fuel oil pump set.
4. Automatic Safety Shut-Off Valves:
   a. Type: Motorized-opening, spring closing, controlled by burner control system. Two valves required.
   b. Service: Provide open-shut control of fuel flow to burner. Valves shall shut bubble-tight and be suitable for operation with upstream pressure exceeding upstream safety relief valve set pressure plus accumulation.
   c. Performance: Timed opening of six seconds or less to safely and smoothly ignite oil burner, one-second closure.
   d. Construction: Threaded ends, valve position indicator visible from front or side of boiler. Closed position interlock switch on each valve.
   e. Approval: FM approved, UL listed for burner service.
   f. Provide valved leak test connections between the two safety shut-off valves and after the second safety shut-off valve.
   g. Proof of Closure Test: Provide non-latching push button controls in the proof of closure circuit to interrupt the circuit when the valves are closed.
5. Pressure Switches: Refer to paragraph, BURNER MANAGEMENT (FLAME SAFEGUARD CONTROL) SYSTEM WITH SAFETY INTERLOCKS AND ACCESSORIES in Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT. Switch settings must be within 20 percent of the controlled pressure. High pressure switches shall have lockable service isolating valves and valved connections for pressurizing the switches and testing the set and trip points.

6. Fuel Flow Control Valve:
   a. Type: Characterized sliding gate valve controlled by combustion control system. Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT
   b. Operated by electric drive unit actuator with top mount integrated digital positioner. Modified linear valve flow characteristics shall be utilized when digital positioner is furnished. Rotary valves or actuators are not acceptable.
   c. Performance and Service: Control fuel flow in exact proportion to combustion airflow over the entire firing range of the burner. Static pressure rating shall exceed the lockup pressure of the boiler-mounted regulator.
   d. Performance: Determined by burner manufacturer.
   e. Sliding Gate Valve: Stainless steel body, head section, actuator springs valve stem and fixed disc. Tribaloy (STN2) self-aligning sliding disc. Carbon filled PTFE packing. Minimum ratings 300 psig @ 280 degrees F. Basis of Design manufacturer: Schubert & Salzer Model GS3 series valve with 8038 electric actuator.
   f. Fuel valve oil turn down capability: minimum of 30:1
7. Pressure Gauges, Thermometers, Flow Meter: Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.
8. Boiler/Burner-Mounted Oil Pump and Relief Valve: Do not provide. House pumps shall include relief valves.

H. Low Pressure Air Atomizing System:
1. Single system furnished by burner manufacturer to serve (3) boilers, and consisting of single receiver, N+1 redundant compressors and drives, air filter, low pressure switch and all piping systems.
2. Motor: Premium efficiency type. Refer to the Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION.
3. Motor Controls: Provide motor starters in NEMA 4 enclosures. Refer to Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION. Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT, for burner management control interlock proving power supply to motor.
4. Sound Attenuators: Provide compressor enclosures, air intake silencers, or other means to reduce sound levels to those required.

Refer to the Section 23 05 51, NOISE AND VIBRATION CONTROL FOR BOILER PLANT.

5. Pressure Gauges and Pressure Switches: Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.

I. Igniter (Pilot) Fuel Train, Burner and Ignition System:

1. Arrangement: Comply with typical arrangement in NFPA 85, Annex A, as modified by the following description. Arrange the system to allow selection of either natural gas or propane for the ignition fuel. Provide separate piping with plug valve, pressure gauge, filter and pressure regulator for natural gas and for propane. Connect to the main burner natural gas service downstream of the main burner pressure regulator. Join the natural gas and propane services by means of a three-way plug valve. Continue with one pipe line including a low pressure switch, pressure gauge, automatic safety shut off valve, automatic vent, automatic safety shut off valve, igniter.
2. Filters: Replaceable elements, five micron or smaller particle retention. Static pressure capability two times the maximum lockup pressure of nearest upstream pressure regulator. Maximum pressure loss, at full flow, 1.3 kPa (5 inches WG). Provide unions for filter removal.
3. Pressure Regulators:
   a. Type: Single-seated, diaphragm-operated. Provide separate regulators for natural gas service and for LP gas service.
   b. Service: Provide controlled pressure in igniter train as required by igniter, with upstream pressures as shown or specified. Inlet and outlet emergency pressure rating shall be at least twice the lockup pressure of the nearest upstream pressure regulator. As an alternate to the outlet emergency pressure rating, provide internal relief valve vented to outside set at pressure that will avoid overpressure on regulator outlet that could damage the regulator.
   c. Performance: Lockup pressure shall not exceed 1.5 times the regulated pressure.
   d. Construction: Propane regulator must be designed for LP gas.

4. Automatic Safety Shut-Off and Vent Valves:
   a. Type: Solenoid-type, two normally closed shut-off valves and one normally-open vent valve, arranged as shown, controlled by the burner control system. Provide threaded leak-test ports with threaded plugs on each shut-off valve body.
   b. Service: Provide open-shut control of fuel flow to igniter and vent between shut-off valves. Design for 138 kPa (20 psig) differential at shut-off.
   c. Approval: Safety shut-off valves UL listed, FM approved for burner service. Vent valves UL listed for burner service.
5. Vent System Manual Plug Valve for Leak Tests: Located on vent line on outlet side of automatic vent valve. Provide locking device and lock wrench to lock valve to open position. Provide cylinder padlock keyed to VA Engineering key. Provide valved leak test connections between automatic vent valve and plug valve and ahead of the automatic vent valve.
6. Igniter and Ignition System: Provide removable igniter, ignition electrodes, ignition transformer, high voltage cable. Provide shield at ignition area so that spark is not visible to flame scanner from any position on its mounting.
7. Igniter fuel train pipe and fittings: ASME B31.1 requirements do not apply. Refer to Section 23 21 11, BOILER PLANT PIPING SYSTEMS.
8. Pressure Switch and Pressure Gauges: Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.

2.4 BURNER MANAGEMENT AND FLAME SAFEGUARD CONTROL SYSTEMS AND ACCESSORIES

A. Provide in accordance with NFPA 85.
B. Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.
C. Control Panel: Controls shall be mounted in a free standing NEMA 4 enclosure on side of boiler or on burner. There shall be no power wiring in this enclosure.
D. Factory Testing: Install controls on boiler and burner at factory and test operation of all devices.

2.5 FLUE GAS ECONOMIZER

A. Heat exchangers to transfer heat from boiler flue gases to boiler feedwater.

B. Type: Rectangular configuration, replaceable finned tubes, up flow flue gas, parallel flow water, insulated casing with removable panels allowing access to all tubes for cleaning and replacement.

C. Performance: Refer to schedules on drawings. Coordinate input flue gas temperatures with data from boiler manufacturer.

D. Construction:

1. Comply with ASME BPVC Section VIII. Design unit to permit operation with no water in the tubes at the temperature listed below.
2. Design Pressure:
   a. Water Tubes, 2070 kPa (300 psig) minimum.
   b. Inner Casings, 2.5 kPa (10 inches WG) minimum.
3. Design Temperature, 371 degrees C (700 degrees F).
4. Tubes and Headers: ASTM A254, Type 316 Stainless steel. Helically wound non-serrated stainless steel fins continuously welded to tubes. 2070 kPa (300 psig) flanged piping connections. Drainable by gravity. Return bend areas shall be exposed to the bulk temperature of the flue gas. Headers shall be external to the casing. Fin density shall not exceed 157 fins per meter (48 fins per foot). Maximum fin height, 15 mm (1/2 inches).
5. Casing: Double wall, removable panels, with insulation between walls. 75 mm (3 inch) angle flanges on flue gas inlet and outlet for attachment of breeching and stack.
   a. Inner Casing, stainless steel, all welded. Steel angles for breeching attachment to casing. Entire casing systems must be gas tight.
   b. Insulation: Mineral fiber, ASTM C612, 50 mm (2 inches) thick.
   c. Outer Casing: Galvanized or painted steel, 0.4 mm (0.016 inches) thick.

E. Accessories:

1. Safety Relief Valve: Valve designed for steam and water service, ASME National Board certified, selected by economizer manufacturer in accordance with ASME Code requirements. Set pressure 1896 kPa (275 psig) gauge.
2. Inlet and Outlet Transitions: Designed and furnished by economizer manufacturer.

F. Factory Test and Inspections: Inspect the completed economizer assembly in accordance with the ASME BPVC Section I. Certify the inspection and submit four copies of completed ASME Form P-3 for each economizer.
G. Provide Valved Station to pressurize economizer with a hand pump to perform safety device testing of liquid relief valve on economizer.

2.6 TOOLS

A. Oil Burner Vise and Wrenches: Deliver to COR for mounting by VA personnel. Furnish only if burners require vise and wrenches not stocked by local tool suppliers.
B. Boiler Tube Brushes: Furnish hand brushes of sizes, and with handle lengths, to clean full length of all tubes in boiler. Provide handle and extension sections 1800 mm (6 feet) long or less to permit storage. Coupled lengths shall be suitable for use from front of boiler.

2.7 SPARE PARTS

A. Fuel Trains:
   1. One of each type and size of main and pilot fuel motorized and solenoid automatic safety shut-off valves and automatic vent valves.
   2. Complete set of filter elements and gaskets for each gas filter for each boiler.
   3. Complete set of all gaskets for each edge-type oil filter for each boiler.
B. Boiler, Burner, Trim, Feedwater Control System:
   1. One assembly of electrodes, transformer, and high voltage lead with end connectors for igniters.
   2. Two complete sets of gaskets, for each boiler, to fit all doors, handholes, manholes.
   3. One clear lens and one tinted lens for each furnace and burner observation port on each boiler.
   4. Sufficient flat glass inserts and gaskets to re-equip water level gauge glasses on each boiler.
   5. One set of drive belts for each belt-driven apparatus for each boiler.
   6. One gallon oil for atomizing air compressor.
   7. Complete set of air compressor intake filter elements for each compressor, for each boiler, if disposable filters are provided.
   8. One complete feedwater control valve and actuator.

PART 3 - EXECUTION

3.1 INSTALLATION

A. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no additional cost or time to the Government.

B. Boiler and Burner Access Openings: Arrange all equipment and piping to allow access to openings without disassembly of equipment or piping. Provide space that permits full opening of all boiler and burner doors, panels and other access openings. Provide space for pulling full length of all boiler tubes directly from their installed location.

C. Drainage Facilities for Boiler Water Column, Gauge Glass, Low Water Cutoffs, Water Level Alarms:

1. Refer to Detail, FIRE TUBE BOILER.
2. Locate and orient sight flow indicators so that one person can view the fluid flow while simultaneously operating drain valves and low water cutoff shunt switches.

D. Boiler Flue Gas Outlet Location: Drawings show a location based on an assumption on the number of passes of the boilers. If the boilers submitted have a different flue gas outlet location, redesign and relocate the stack and breeching systems, at no additional cost or time to the Government.

E. Boiler Casing Flashing: Flash or seal all openings in the casing at the top of the boiler at the piping and the flue penetrations to prevent leakage of water into the boiler insulation.

3.2 CLEANING AND PROTECTION FROM CORROSION

A. Refer to Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION.

B. Boiler Cleaning:

1. Upon completion of installation, the initial firing of the burner shall be performed to boil out, under supervision of boiler manufacturer, all internal surfaces with chemical solution recommended by boiler manufacturer, to remove all mill scale, corrosion products and other foreign material. Following boil out, boiler shall be washed and flushed until water leaving the boiler is clear. Drain boiler, inspect internal surfaces for cleanliness, then refill boiler with softened and treated water.

2. Refer to the paragraph, INSPECTIONS AND TESTS for requirements for cleaning boiler after operational tests are completed.

C. Protection from Corrosion:
   1. Protect the boilers from fire-side and water-side corrosion at all times.
   2. Dry Storage: When the boilers are not filled with water, protect the water-sides and fire-sides with a dry storage method recommended by either the boiler manufacturer or the ASME BPVC Section VII.
   3. Wet Storage: If, after water is placed in the boilers, they are not fired for equipment adjustment or testing for more than two weeks, the boilers shall be protected with a wet storage method recommended either by the boiler manufacturer or the ASME BPVC Section VII.
   4. Chemical Treatment: The quality of the water in the boilers shall be maintained by a professional water treatment organization. This organization shall provide onsite supervision to maintain the required water quality during periods of boiler storage, operating, standby and test conditions. Furnish monthly reports by the water treatment organization, to the COR. The Contractor shall provide all chemicals, labor and professional services until the boilers have been accepted by the Government for operation. All chemicals utilized must conform to FDA Regulation CFR 21, 173.310, guidelines applicable for steam used in food preparation.

3.3 INSPECTIONS AND TESTS

A. The following tests and demonstrations must be witnessed by the COR or his/her representative, and must prove that boilers, economizers, burners, controls, instruments, and accessories comply with requirements. Refer to Section 23 08 11, DEMONSTRATIONS AND TESTS FOR BOILER PLANT for general requirements. When test results are not acceptable, make corrections and repeat tests at no additional cost or time to the Government. All safety devices shall be tested in accordance with the VHA Boiler Plant Safety Devices Testing Manual and all construction documents. The VA will not take beneficial use of equipment until all safety devices pass the required tests. Pretests do not require the presence of the COR. Evidence of the tests shall include completed sign-in sheet and test checklists from the VHA Boiler Plant Safety Devices Testing Manual, which shall be filled out completely for all equipment that has been provided by, or directly or indirectly affected by, the project.

B. Manufacturer Certification at Start-Up: The boiler manufacturer shall certify that the equipment furnished has been installed, connected, and tested in accordance with the manufacturer’s installation and operating instructions.

C. Condition of Boiler and Economizer After Delivery, Rigging, Placement: After setting boiler on foundation and placing economizer on supports, and prior to making any connections to boiler and economizer, the Contractor and COR shall jointly inspect interior and exterior for damage. Correct all damage by repair or replacement to achieve a like new condition.

D. Hydrostatic Tests:

1. Boiler, Economizer: Contractor shall provide inspector certified by National Board of Boiler and Pressure Vessel Inspectors (NBBI) to conduct tests after equipment is installed and connected for operation and prior to initial firing. Test pressure shall be 1-1/2 times the design pressure of the boiler for a period required by the inspector. Provide written certification of the satisfactory test, signed by the inspector. Correct any deficiencies discovered during the testing, and retest equipment until satisfactory results are achieved and are accepted by the inspector. The COR or his/her representative shall be present for inspections and tests.
2. Boiler External Piping (as defined by ASME B31.1):
   a. Refer to Section 23 21 11, BOILER PLANT PIPING SYSTEMS.
   b. Test may be conducted concurrently with boiler and economizer testing.
3. Identify and remove any connecting equipment which is not rated for the test pressure. Cap the openings left by the disconnected equipment. Reinstall the equipment after tests are completed.

E. Boiler Steam Safety Valves:

1. Test each valve set pressure and blowdown pressure with boiler steam pressure. Perform accumulation test by operating burner at high fire to verify that safety valve flow capacity is sufficient to handle the maximum boiler steaming rate. Tests shall be performed with

boiler isolated from the main steam header and all generated steam exhausting through the safety valves.

2. Valve Popping Tolerance: Plus or minus three percent of set pressure for set pressures over 480 kPa (70 psig) gauge.
3. Valve Blowdown Tolerance: Reset at not less than 6 percent below set pressure of valve with the lowest set pressure. Minimum blowdown two percent of the set pressure.
4. Accumulation Test: With burner at high fire, the boiler pressure shall not rise more than six percent above the set pressure of the safety valve with highest pressure setting and shall remain below the maximum allowable working pressure of the boiler.

F. Burner Management (Flame Safeguard Control) System:

1. Demonstrate operation of all control, interlock and indicating functions. Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.
2. Prior to scheduling final test submit certification that all control, indicating, and interlock functions have been pretested.
3. Conduct final test immediately prior to boiler-burner tests.
4. Experienced personnel representing the manufacturer of the system shall conduct the tests.

G. Performance Testing of Boiler, Burner, Economizer, Combustion Control, Boiler Plant Instrumentation:

1. Perform tests on each boiler on all main burner fuels.
2. If required by local emissions authorities, provide services of testing firm to determine NOx and carbon monoxide. Test firm shall be acceptable to emissions authorities.
3. Test No. P-1:
   a. Operate boiler on each fuel, with economizer in service and record data for at least eleven evenly spaced steam loads from low fire start to 100 percent of full steam output, and in the same sequence back to low fire. Demonstrate performance and efficiency required by paragraphs, BOILER, BURNER AND FUEL TRAINS, and FLUE GAS ECONOMIZER and by boiler and economizer equipment lists on drawings.
   b. Demonstrate proper operation of combustion controls, draft control, feedwater level controls, and instrumentation systems.

Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.

c. When flue gas oxygen trim is provided, conduct tests with trim control on manual at the zero trim (null) position. Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT. After completion of tests with trim control on manual control, repeat the tests on one fuel with the trim control on automatic control.

4. Test No. P-2:
   a. Demonstrate sound level of fans and burner systems and atomizing air compressor.
   b. Test point shall be at 100 percent of maximum boiler load.
   c. Refer to sound level requirements in Section 23 05 51, NOISE AND VIBRATION CONTROL FOR BOILER PLANT.
5. Test No. P-3:
   a. Check current draw of forced draft fan motor at prepurge and at 100 percent of maximum boiler load.
   b. Current draw shall not exceed full load current stamped on motor nameplate.
   c. This test may be combined with Test No. P-1.
6. Test Methods:
   a. Utilize permanent instrumentation systems for data. All systems shall be operable and in calibration.
   b. Utilize portable thermocouple pyrometer furnished and retained by Contractor to measure stack temperature as a verification of permanent stack temperature recorder.
   c. Use portable electronic flue gas analyzer to determine constituents of flue gas. Analyzer shall be capable of measuring oxygen in per cent with accuracy of plus or minus 0.5 percent oxygen and carbon monoxide in ppm with accuracy of plus or minus 5 percent of reading (Range 0 to 1000 ppm). Obtain oxygen and carbon monoxide readings at each test point. Calibrate instrument with certified test gases within three months prior to use and immediately after analyzer cell replacement.

d. In Test No. P-1 retain boiler at each load point for a time period sufficient to permit stabilization of flue gas temperature and other parameters.
e. Steam loads for tests may be furnished by the hospital systems, by operation of the steam silencer vent system, or by a combination of the above. If variable hospital loads interfere with testing, conduct tests at night or on weekends when loads are more stable.
f. Utilize dry bulb and wet bulb thermometers furnished and retained by Contractor for checking combustion air.
g. Smoke testing shall be by visual observation of the stack and by smoke density monitor (permanent instrument - if provided). If smoke density monitor is not provided, utilize Bacharach Model 21-7006 Smoke Test Kit. If there is disagreement with the results of these tests, provide qualified observation person and tests in compliance with EPA Reference Method 9 (CFR 40, Part 60, Appendix A).
h. Sound level instruments will be Government furnished.
i. NOx emissions shall be tested with electronic analyzer reading in ppm. Analyzer shall be calibrated with certified test gas within three months prior to use. Analyzer shall be accurate to plus or minus 5 percent of reading.
j. An additional efficiency test will be required, conforming to ASME PTC 4, if the boiler efficiency determined in the Test P-1 above, does not comply with requirements. Utilize ASME Test Forms and the abbreviated input-output and heat balance methods.

7. Pretesting:
   a. Perform pretest at the final stage of the burner fine-tuning process.
   b. Prior to scheduling final test, submit evidence of pretest. Evidence shall consist of start-up data sheets signed and dated by personnel representing burner manufacturer, combustion controls manufacturer, burner controls manufacturer. Evidence of the tests shall also include completed sign-in sheet and test checklists from the VHA Boiler Plant Safety Devices Testing Manual, which shall be filled out completely for all equipment

that has been provided by, or directly or indirectly affected by, the project.

c. Pretest data sheets shall list the following data for each fuel and at each fuel valve controller position, starting at minimum position, proceeding to the maximum position and returning to the minimum position.
   1) Fuel flow and air flow controller position.
   2) Fuel pressures: At burner and also upstream of fuel flow control valve.
   3) Fuel flow rate.
   4) Boiler feed pressure, upstream of feedwater regulator (at minimum, 50 percent, maximum firing positions only).
   5) Boiler feed temperature (at minimum, 50 percent, maximum firing positions only.
   6) Stack temperature: Boiler outlet, economizer (if provided) outlet.
   7) Flue gas oxygen and carbon monoxide (utilize flue gas analyzer which has been calibrated with certified test gases).
   8) Steam flow rate (at minimum, 50 percent, maximum firing position only).
   9) Steam pressure - Boiler, Header (at minimum, 50 percent, maximum positions only).
   10) Opacity of flue gas.
   11) Flue gas NOx (if limit specified).
   12) Combustion air temperature - dry bulb and wet bulb.
   13) Barometric pressure (one reading).

d. Calibrate all pressure gauges prior to pretest.

H. Internal Inspection of Pressure Parts and Furnace:
   1. After all operational tests are satisfactorily completed, a Government retained, licensed boiler inspector will determine if the boiler is free from corrosion, deposits, and any other type of damage or defect.
   2. In preparation for the inspection, open all manways, handholes, and access doors or panels at the ends of the boiler. Drain and clean the interior of all pressure parts and clean all soot and debris from furnace and fire tubes.

3. Any corrosion, damage or defect shall be corrected to a like new condition in the judgment of the boiler inspector.
4. After the boiler inspector has approved the boiler, all manways, handholes, and the access doors shall be closed with new gaskets.

I. If burner operation results in deposits of carbonaceous materials in the furnace or tubes clean the furnace and tubes, modify the burners as necessary, and retest the burner performance and safety devices, as the safety device settings can be affected by burner adjustments.

J. Any retests required as a result of failed tests shall be performed at no additional cost to the Government. Costs incurred by the Government as a result of witnessing failed tests shall become the responsibility of the contractor, and the Government may choose to withhold contract payment equal to the value of such costs.

3.4 STARTUP AND TESTING

A. Perform tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.

B. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.

C. 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 notice of 10 working days prior to startup and testing.

3.5 COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

B. Components provided under this section of the specification will be tested as part of a larger system.

3.6 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer’s technical representative for 12 hours to instruct each VA personnel responsible in the operation and maintenance of the system.

B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

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SECTION 23 72 00
AIR-TO-AIR ENERGY RECOVERY EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. This Section specifies air-to-air plate heat exchangers.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS: Requirements for pre-test of equipment.

B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.

C. Section 01 91 00 – GENERAL COMMISSIONING REQUIREMENTS

D. Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS: Seismic requirements for non-structural equipment.

E. 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.

F. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION EQUIPMENT.

G. Section 23 05 93, TESTING, ADJUSTING and BALANCING FOR HVAC: Requirements for testing, adjusting and balancing of HVAC system.

H. Section 23 07 11, HVAC and BOILER PLANT INSULATION: Requirements for piping insulation.

I. Section 23 08 00 – COMMISSIONING OF HVAC SYSTEMS: Requirements for commissioning, systems readiness checklists, and training.

J. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC: Requirements for controls and instrumentation.

K. Section 23 21 13, HYDRONIC PIPING: Requirements for piping for expansion tanks.

L. Section 23 31 00, HVAC DUCTS and CASINGS: Requirements for sheet metal ducts and fittings.

M. Section 23 40 00, HVAC AIR CLEANING DEVICES: Requirements for filters used before heat recovery coils.

N. Section 23 82 16, AIR COILS: Requirements for run-around system coils.

1.3 QUALITY ASSURANCE

A. Refer to specification Section 01 00 00, GENERAL REQUIREMENTS for performance tests and instructions to VA personnel.

B. Refer to paragraph QUALITY ASSURANCE in specification Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

C. 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.

D. 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)

1060-2018..............Performance Rating of Air-to-Air Heat Exchangers for Energy Recovery Ventilation Equipment

C. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE):

15-2019.................Safety Standard for Refrigeration Systems (ANSI)

52.1-1999...............Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter

52.2-2017...............Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size

62.1-2016...............Ventilation for Acceptable Indoor Air Quality

84-2013.................Method of Testing Air-to-Air Heat/Energy Exchangers

D. American Society for Testing and materials (ASTM)

D635-2018...............Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position

E84-2014................Standard Test Method for Surface Burning Characteristics of Building Materials

E. American Society of Civil Engineers (ASCE)

ASCE 7-2017.............Minimum Design Loads for Buildings and Other Structures

F. Underwriters Laboratories, Inc (UL)

1812-2013...............Standard for Ducted Heat Recovery Ventilators

1815-2015...............Standard for Nonducted Heat Recovery Ventilators

PART 2 - PRODUCTS

2.1 AIR-TO-AIR PLATE HEAT EXCHANGER

A. Comply with UL Standard~~s~~ 1812.

B. Plates: Corrugated 0.53 mm (0.021 inch)Partition, spacing plate-cellulose fiber membrance) spacing as recommended by the manufacturer.

C. Bedding: Thermosetting reinforced resin. Provide plate seal-off and passage separation at top, bottom and center divider. The resins shall be self-extinguishing type in accordance with ASTM D635.

D. Casing and End Strips: Casing of 1.6 mm (16 gage) galvanized steel, except casings for corrosive air streams shall be stainless steel. End strips of the same material as exchanger plates. Ends of unit exchanger plates shall be sealed with high temperature silicon sealant prior to installation of end strip for corrosive air streams provide welded end strips to avoid cross contaminations.

E. Casings shall have integral flanges for flanged duct connections and shall have lifting holes or lugs.

F. Drain Pan: Same material as unit casing. Drain-pan surface shall be covered with molded ABS, and shall have drain connections on exhaust and supply side. Comply with requirements in ASHRAE 62.1.

G. Accessories: Furnish where indicated on the drawings.

1. Face and Bypass Dampers: Manufacturer's standard, complete with operators, with factory-installed controls to operate face-and-bypass dampers during summer and winter.

H. Extended-Surface, Disposable Panel Filters: MERV 7, 2-inch throw-away type. Refer to Section 23 40 00 HVAC Air Cleaning Devices.

2.5 AIR FILTERS

A. Air Filters: Disposable air filters, with a MERV rating of 7, shall be provided standard on all air entering sides of air-to-air heat exchangers and as indicated on the drawings. Comply with requirements in specification 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 the Seismic area according to specification Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.

3.2 FIELD QUALITY CONTROL

A. Operational Test: Perform tests as per manufacturer’s written instructions for proper and safe operation of the heat recovery system.

1. After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Adjust seals and purge.
3. Test and adjust controls and safeties.

B. Replace damaged and malfunctioning controls and equipment.

C. Set initial temperature and humidity set points. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

D. Prepare test and inspection reports to the COR in accordance with 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 81 00
DECENTRALIZED UNITARY HVAC EQUIPMENT

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies split-systems and rooftop and

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 (EER): 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. 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.
4. 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.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES

C. Section 03 30 00, CAST-IN-PLACE CONCRETE.

D. Section 07 72 00, ROOF ACCESSORIES.

E. Section 23 05 11, COMMON WORK RESULTS FOR HVAC.

F. Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION EQUIPMENT

G. Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.

H. Section 23 05 93, TESTING, ADJUSTING, and BALANCING FOR HVAC.

I. Section 23 07 11, HVAC and BOILER PLANT INSULATION.

J. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

K. Section 23 09 23, DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC.

L. Section 23 11 23, FACILITY NATURAL-GAS PIPING.

M. Section 23 23 00, REFRIGERANT PIPING.

N. Section 23 31 00, HVAC DUCTS and CASINGS.

O. Section 23 72 00, AIR-TO-AIR ENERGY RECOVERY EQUIPMENT.

P. Section 23 82 16, AIR COILS

Q. Section 28 31 00, FIRE DETECTION and ALARM.

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:

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) Self-contained units
      2) Split systems
      3) Rooftop units
   b. Window air conditioners
   c. Through-the-wall packaged terminal air conditioning units
   d. Gas-Fired Furnaces
2. Unit Dimensions required clearances, operating weights accessories and start-up instructions.
3. Electrical requirements, wiring diagrams, interlocking and control wiring showing factory installed and portions to be field installed.
4. Mounting and flashing of the roof curb to the roofing structure with coordinating requirements for the roof membrane system.

C. Certification: Submit proof of specified ARI Certification.

D. Performance Rating: Submit catalog selection data showing equipment ratings and compliance with required sensible-to-heat-ratio, energy efficiency ratio (EER), and coefficient of performance (COP).

E. Operating and Maintenance Manual: Submit three copies of Operating and Maintenance manual to COR three weeks prior to final inspection.

F. Completed System Readiness Checklists provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion, in accordance with the requirements of Section 23 08 00 COMMISSIONING OF HVAC SYSTEMS.

1.5 APPLICABLE PUBLICATIONS

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.

B. Air-Conditioning, Heating, and Refrigeration Institute (AHRI):

210/240-2017...........Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment

270-2015................Sound Rating of Outdoor Unitary Equipment

310/380-2017...........Standard for Packaged Terminal Air-Conditioners and Heat Pumps (CSA-C744-04)

340/360-2015...........Performance Rating of Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment

520-2004................Performance Rating of Positive Displacement Condensing Units

C. Air Movement and Control Association (AMCA):

210-2016................Laboratory Methods of Testing Fans for Aerodynamic Performance Rating (ANSI)

410-1996................Recommended Safety Practices for Users and Installers of Industrial and Commercial Fans

D. American National Standards Institute (ANSI):

S12.51-2017............Acoustics - Determination of Sound Power Levels of Noise Sources Using Sound Pressure - Precision Method for Reverberation Rooms (same as ISO 3741:1999)

E. American Society of Civil Engineers (ASCE)

ASCE 7-2017............Minimum Design Loads for Buildings and Other Structures

F. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):

Handbook 2016..........HVAC Systems and Equipment

15-2019.................Safety Standard for Refrigeration Systems (ANSI)

62.1-2016...............Ventilation for Acceptable Indoor Air Quality (ANSI)

G. American Society of Testing and Materials (ASTM):

B117-2018...............Standard Practice for Operating Salt Spray (Fog) Apparatus

H. Federal Specifications (Fed. Spec.):

A-A-50502-2009.......... Air conditioner (Unitary Heat Pump) Air to Air (3000-300,000 Btu)

I. Military Specifications (Mil. Specs.):

MIL-PRF-26915D-2006.....Primer Coating, for Steel Surfaces

J. National Electrical Manufacturer's Association (NEMA):

ICS 1-2005..............Industrial Controls and Systems: General Requirements

MG 1-2019...............Motors and Generators (ANSI)

K. National Fire Protection Association (NFPA) Publications:

90A-2018................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.

2.3 SPLIT-SYSTEM AIR CONDITIONERS

A. Description: Factory assembled and tested, floor-mounted, wall-mounted unit, with an air- cooled remote condensing unit, and field-installed refrigeration piping. Unit shall include a electric-resistance heating coil.

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.
4. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
5. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with AHRI 210/240, and with thermal-expansion valve.
7. Electric-Resistance Heating Coil: Helical, nickel-chrome, resistance-wire heating elements with refractory ceramic support bushings; automatic-reset thermal cutout; built-in magnetic contactors; manual-reset thermal cutout; airflow proving device; and one-time fuses in terminal box for overcurrent protection. Provide SCR control of electric heating coils as indicated.
8. Fan: Forward-curved, double-width wheel of galvanized steel; directly connected to motor.
9. 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.

10. Disposable Filters: 25 mm (1 inch) thick, in fiberboard frames with MERV rating of 7 or higher according to ASHRAE 52.2 .
11. 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.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
6. Coils:
   a. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with AHRI 210/240, and with thermal-expansion valve.
   c. Electric-Resistance Heating Coil: Helical, nickel-chrome, resistance-wire heating elements with refractory ceramic support bushings; automatic-reset thermal cutout; built-in magnetic contactors; manual-reset thermal cutout; airflow proving device; and one-time fuses in terminal box for overcurrent protection. Provide SCR control of electric heating coils as indicated.
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. Drain Pan and Drain Connection: Comply with ASHRAE 62.1-2007.
4. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with AHRI 210/240, and with thermal-expansion valve.
5. Electric-Resistance Heating Coil: Helical, nickel-chrome, resistance-wire heating elements with refractory ceramic support bushings; automatic-reset thermal cutout; built-in magnetic contactors; manual-reset thermal cutout; airflow proving device; and one-time fuses in terminal box for overcurrent protection.
6. Fan: Direct drive, centrifugal fan.
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. 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.
3. Drain Pan and Drain Connection: Comply with ASHRAE 62.1.
4. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with AHRI 210/240, and with thermal-expansion valve.
5. Electric-Resistance Heating Coil: Helical, nickel-chrome, resistance-wire heating elements with refractory ceramic support bushings; automatic-reset thermal cutout; built-in magnetic contactors; manual-reset thermal cutout; airflow proving device; and one-time fuses in terminal box for overcurrent protection.
6. Fan: Direct drive, centrifugal fan, and integral condensate pump.
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. 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.
10. Minimum Energy Efficiency: Comply with ASHRAE/IESNA 90.1 "Energy Standard for Buildings except Low-Rise Residential Buildings."

2.4 ROOFTOP AIR CONDITIONERS

A. Casing: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed. Exterior casing of 1.3 mm (0.052 inch) thick galvanized steel with factory-painted finish, with pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs. Galvanized inner casing of 0.86 mm (0.034 inch) thick, . Casing insulation and adhesive shall comply with NFPA 90A or NFPA 90B and comply with ASTM C 1071, Type I and shall be 13 mm (1/2 inch) thick. Space between double wall panels filled with foam insulation and sealed moisture tight. Removable cam latched access panel to allow access to internal parts.

B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Supply-Air Fan: Belt-driven, double width, forward curved, centrifugal; with permanently lubricated, single-speed motor installed on an adjustable fan base resiliently mounted in the casing. Fan wheel shall be aluminum or painted-steel and fan scroll shall be galvanized- or painted-steel.

D. Condenser-Coil Fan: Propeller, mounted on shaft of permanently lubricated motor.

E. Seismic Fabrication Requirements: Fabricate fan section, internal mounting frame and attachment to fans, fan housings, motors, casings, accessories, and other fan section components with reinforcement strong enough to withstand seismic forces defined in Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT when fan-mounted frame and RTU-mounted frame are anchored to building structure.

F. Fan Motor: Comply with requirements in Section 23 05 12, GENERAL MOTOR REQUIREMENTS FOR HVAC and STEAM GENERATION EQUIPMENT.

G. Supply-Air Refrigerant Coil: Aluminum copper tube in steel casing with equalizing-type vertical distributor. Polymer strip shall prevent all copper coil from contacting steel coil frame or condensate pan. Coil split shall be interlaced. Coil shall have baked phenolic coating.

H. Condensate Drain Pan: Formed sections of stainless-steel sheet, a minimum of 50 mm (2 inches) deep and complying with ASHRAE 62.1. Drain connections shall be threaded nipple.

I. Electric-Resistance Heating Coil: Resistance wire of 80 percent nickel and 20 percent chromium, supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.

   1. Terminals: Stainless-steel machine-staked terminals secured with stainless-steel hardware.
   2. Overtemperature Protection: Disk-type, automatically reset, thermal-cutout, safety device; serviceable through terminal box.
   3. Overcurrent Protection: Manual-reset thermal cutouts, factory wired in each heater stage.
   4. Control Panel: Unit mounted with disconnecting means and overcurrent protection and shall include magnetic contactors.

5. Step Controller: Have pilot lights and override toggle switch for each step.
6. SCR Controller: Have pilot lights operate on load ratio, a minimum of five steps.
7. Time-delay relay.
8. Airflow proving switch.

J. Refrigerant Circuit Components:
   1. Number of Independent Refrigerant Circuits: One.
   2. Compressor: Hermetic, scroll, mounted on vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief , and crankcase heater .

K. Refrigerant: R-410A unless otherwise indicated.

L. Refrigeration Specialties:
   1. Expansion valve with replaceable thermostatic element.
   2. Refrigerant filter/dryer.
   3. Manual-reset high-pressure safety switch.
   4. Automatic-reset low-pressure safety switch.
   5. Minimum off-time relay.
   6. Automatic-reset compressor motor thermal overload.
   7. Brass service valves installed in compressor suction and liquid lines.
   8. Low-ambient kit high-pressure sensor.

M. Air Filtration: Minimum arrestance according to ASHRAE 52.1, and MERV rating according to ASHRAE 52.2.
   1. Pleated: Minimum 90 percent arrestee, and MERV 13.

N. Outdoor-Air Damper: Linked damper blades, for 0 to 25 percent outdoor air, with motorized damper filter.

O. Outdoor- and Return-Air Mixing Dampers: Parallel- or opposed-blade galvanized-steel dampers mechanically fastened to cadmium plated for galvanized-steel operating rod in reinforced cabinet. Connect operating rods with common linkage and interconnect linkages so dampers operate simultaneously.

P. Damper Motor: Modulating with adjustable minimum position.

Q. Relief-Air Damper: Gravity actuated or motorized, complying with ASHRAE/IESNA 90.1, and having bird screen and hood.

R. Electrical Power Connection: A single connection of power to unit with unit-mounted disconnect switch accessible from outside unit and control-circuit transformer with built-in overcurrent protection.

S. Controls:

1. Basic Unit Controls:
   a. Control-voltage transformer.
   b. Wall-mounted thermostat or sensor with heat-cool-off switch.
   c. Fan on-auto switch.
   d. Fan-speed switch.
   e. Automatic changeover.
   f. Adjustable deadband.
   g. Exposed set point.
   h. Exposed indication.
   i. Degree F indication.
   j. Unoccupied-period-override push button.
   k. Data entry and access port to input temperature set points, occupied and unoccupied periods, and output room temperature, supply-air temperature, operating mode, and status.
   l. Remote wall Unit-mounted annunciator panel with lights to indicate power on, cooling, heating, fan running, filter dirty, and unit alarm or failure.
   m. DDC controller or programmable timer and interface with HVAC instrumentation and control system and to digital display outdoor-air temperature, supply-air temperature, return-air temperature, economizer damper position, indoor-air quality, and control parameters. Interface with BMS/DDC system via BACnet open protocol.
2. DDC controller shall have volatile-memory backup.
3. Safety Control Operation:
   a. Smoke Detectors: Stop fan and close outdoor-air damper if smoke is detected and with additional contacts for alarm interface to fire alarm control panel.
   b. Fire Stats: Stop fan and close outdoor-air damper if air greater than 54 deg C (130 deg F)] enters unit and with additional contacts for alarm interface to fire alarm control panel.

c. Fire Alarm Control Panel Interface: Control interface to coordinate with operating sequence described in Section 28 31 00, FIRE DETECTION and ALARM.

d. Low-Discharge Temperature: Stop fan and close outdoor-air damper if supply air temperature is less than 4 deg C (40 deg F)].

e. Defrost Control for Condenser Coil: Pressure differential switch to initiate defrost sequence.

4. Scheduled Operation: Occupied and unoccupied periods on 7 / 365 / 7-day clock with a minimum of 2 programmable periods per day.
5. Unoccupied Period: Heating Setback: 5.6 deg C (10 deg F)].
6. Cooling Setback: System off.
7. Override Operation: Two hours unless otherwise indicated.
8. Supply Fan Operation:
   a. Occupied Periods: Run fan continuously.
   b. Unoccupied Periods: Cycle fan to maintain setback temperature.
9. Refrigerant Circuit Operation:
   a. Occupied Periods: Cycle or stage compressors and operate hot-gas bypass to match compressor output to cooling load to maintain room temperature . Cycle condenser fans to maintain maximum hot-gas pressure. Operate low-ambient control kit to maintain minimum hot-gas pressure.
   b. Unoccupied Periods: Compressors off
10. Electric-Resistance Heating-Coil Operation:
    a. Occupied Periods: Modulate coil to maintain room temperature.
    b. Unoccupied Periods: Energize coil to maintain setback temperature.
    c. Supplemental Electric Heat Operation: Electric-resistance heating coil with compressor for heating with outdoor temperature below minus 4 deg C (25 deg F).
11. Fixed Minimum Outdoor-Air Damper Operation:
    a. Occupied Periods: Open to 25 percent.
    b. Unoccupied Periods: Close the outdoor-air damper.
12. Economizer Outdoor-Air Damper Operation:
    a. Occupied Periods: Open to 10 percent fixed minimum intake, and maximum 100 percent of the fan capacity to comply with ASHRAE Cycle II. Controller shall permit air-side economizer operation

when outdoor air is less than 15 deg C (60 deg F). Use outdoor-air temperature to adjust mixing dampers. Start relief-air fan with end switch on outdoor-air damper. During economizer cycle operation, lock out cooling.

b. Unoccupied Periods: Close outdoor-air damper and open return-air damper.

13. Interface Requirements for HVAC Instrumentation and Control System:
    a. Interface relay for scheduled operation.
    b. Interface relay to provide indication of fault at the central workstation and diagnostic code storage.
    c. Compatible with BACnet for central HVAC control workstation for adjusting set points, monitoring supply fan start, stop, and operation, inquiring data to include outdoor-air damper position, supply- and room-air temperature and humidity, monitoring occupied and unoccupied operations, monitoring constant and variable motor loads, monitoring variable-frequency drive operation, monitoring cooling load, monitoring economizer cycles and monitoring air-distribution static pressure and ventilation air volume.

T. Accessories:
1. Electric heater with integral thermostat maintains minimum 10 deg C (50 deg F) temperature in gas burner compartment.
2. Duplex, 115-V, ground-fault-interrupter outlet with 15-A overcurrent protection. Include transformer if required. Outlet shall be energized even if the unit main disconnect is open.
3. Low-ambient kit using variable-speed condenser fans for operation down to -17.8 deg C (0 deg F).
3. Filter differential pressure switch with sensor tubing on both sides of filter. Set for final filter pressure loss.
4. Coil guards of painted, galvanized-steel wire.
5. Hail guards of galvanized steel painted to match casing.

U. Roof curbs: Vibration isolators and wind or seismic restraints shall be as specified in Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT. Manufacturer's standard curbs constructed of galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.

1. Curb Insulation and Adhesive: Factory applied and complying with NFPA 90A or NFPA 90B and ASTM C 1071, Type I or II. Thickness shall be / 38 mm (1-1/2 inches) Insulation shall be applied with adhesive and mechanical fasteners to the internal surface of curb. Liner adhesive shall comply with ASTM C 916, Type I. Liner shall be fastened with mechanical fasteners of galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied without causing leakage in cabinet. Liner materials shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity. Liner adhesive shall comply with ASTM C 916, Type I.
2. Curb Height: 355 mm (14 inches)
3. Wind and Seismic Restraints: Metal brackets compatible with the curb and casing, painted to match RTU, used to anchor unit to the curb, and designed for loads at Project site. Comply with requirements in Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT for wind-load requirements.

PART 3 EXECUTION

3.1 INSTALLATION

A. Roof Curb: Install on roof structure or concrete base, level and secure, according to ARI Guideline B. Install RTUs on curbs and coordinate roof penetrations and flashing with roof construction specified in Section 07 72 00, ROOF ACCESSORIES. Secure RTUs to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts.

B. Rooftop Unit Support: Install unit level on structural curbs. Coordinate roof penetrations and flashing with roof construction. Secure rooftop units to structural support with anchor bolts.

C. Install wind and seismic restraints according to manufacturer's written instructions. Wind and seismically restrained vibration isolation roof-curb rails are specified in Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT.

D. Install units level and plumb maintaining manufacturer’s recommended clearances and tolerances.

E. Install water-cooled units with thermometer and pressure gage at the water supply and return connection.

F. Install vibration spring isolators under base of self-contained unit, with minimum static deflection of 25 mm (1 inch) unless otherwise indicated. Refer to Section 23 05 41, NOISE and VIBRATION CONTROL FOR HVAC PIPING and EQUIPMENT

G. Install ground-mounting, compressor-condenser components on 100 mm (4-inch) thick, reinforced concrete base; 100 mm (4 inches) larger on each side than unit. Concrete, reinforcement, and formwork are specified in Section 03 30 00, CAST-IN-PLACE CONCRETE. Coordinate anchor installation with concrete base.

H. Install ground-mounting, compressor-condenser components on polyethylene mounting base.

I. Install roof-mounting compressor-condenser components on equipment supports specified in Section 07 72 00, ROOF ACCESSORIES. Anchor units to supports with removable, cadmium-plated fasteners.

J. Install seismic restraints.

K. 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.

L. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

M. 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. Gas Piping: Comply with applicable requirements in Section 23 11 23, FACILITY NATURAL-GAS PIPING. Connect gas piping to burner, full size of gas train inlet, and connect with union and shutoff valve with sufficient clearance for burner removal and service.

E. Install ducts to termination at top of roof curb. Cut roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.

F. Connect supply ducts to units with flexible duct connectors specified in Section 23 31 00, HVAC DUCTS and CASINGS.

G. Install return-air duct continuously through roof structure.

H. Install normal-weight, 20.7-MPa (3000-psi), compressive strength (28-day) concrete mix inside roof curb, 100 mm (4 inches) thick.

I. Ground equipment and install power wiring, switches, and controls for self-contained and split systems.

J. 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.

K. Install ducts to the units with flexible duct connections.

L. Connect piping with shutoff duty valves on the supply and return side of the coil and unions at all connections and with a throttling valve on the return piping near the coil.

M. Connect piping with shutoff duty valves on the supply and return side of the water-cooled condenser and unions at all connections and with a throttling valve on the return piping near the condenser

N. Connect piping with shutoff duty valves and unions on the steam supply and condensate side of the steam coil. On the condensate line near the coil provide a strainer, trap and shutoff valve.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections: After installing units and after electrical circuitry has been energized, test units for compliance with requirements. Inspect for and remove shipping bolts, blocks, and tie-down straps. After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment. Remove and replace malfunctioning units and retest as specified above.

3.4 STARTUP AND TESTING

A. 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.

B. Provide services of manufacturer's technical representative for four hours to instruct VA personnel in operation and maintenance of units.

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 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 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES

B. Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS

C. Section 23 05 11, COMMON WORK RESULTS FOR HVAC

D. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS

E. Section 23 09 23, DDC SYSTEMS for HVAC

F. Section 23 31 00, HVAC DUCTS AND CASINGS

G. SECTION 23 72 00, AIR TO AIR ENERGY RECOVERY EQUIPMENT

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 4l0 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. 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 4l0-2011..........Forced-Circulation Air-Cooling and Air-Heating Coils
C. American Society for Testing and Materials (ASTM):
   B75/75M-2020...........Standard Specifications for Seamless Copper Tube
D. National Fire Protection Association (NFPA):
   70-2020................National Electric Code
E. National Electric Manufacturers Association (NEMA):
   250-2014...............Enclosures for Electrical Equipment (1,000 Volts Maximum)

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.
F. Coil Casing: 1.6 mm (l6 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 kPa (PSIG):

Pressure	Water Coil	Steam Coil	Refrigerant Coil
Test	2070 (300)	1725 (250)	2070 (300)
Working	1380 (200)	520 (75)	1725 (250)

H. Protection: Unless protected by the coil casing, provide cardboard, plywood, or plastic material at the factory to protect tube and finned surfaces during shipping and construction activities.
I. Vents and Drain: Coils that are not vented or drainable by the piping system shall have capped vent/drain connections extended through coil casing.

2.2 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 Article 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:

   l. 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.

C. Cleanable Tube Type; manufacturer standard:

   l. Well water applications.

   2. Waste water applications.

2.4 VOLATILE REFRIGERANT COILS

A. Continuous circuit, straight tubes, dry expansion type equipped with multi-port distribution header, less expansion valve.

B. Minimum 16 mm (5/8-inch) tube diameter.

C. Designed for R22 or other EPA approved refrigerants.

2.5 ELECTRIC HEATING COILS

A. Standards: ARI 4l0 is not applicable. Electric coils shall meet the requirements of the National Electric Code (NEC-250) and UL 2020.

B. General: Aluminized steel frame, spot welded. Duct mounted units may be flanged or slip-in design with built-in terminal box completely factory wired to terminals. Control panels for coils in air handling units may be built-in or remote in NEMA l enclosure.

C. Coils: Open type, 80 percent nickel, 20 percent chromium resistance wire, insulated by floating ceramic bushings and supported in aluminized steel brackets spaced on 100 mm (4-inch) maximum centers. Coils shall be mechanically crimped in stainless steel terminals which are insulated from the frame with high temperature molded phenolic bushings.

D. Over Temperature Protection:

   l. Primary system: Automatic reset thermal cutout.

   2. Secondary system: Load-carrying manual reset thermal cutout factory wired in series with each heater stage.

E. Overcurrent Protection: Comply with UL and NEC.

F. Contactors: Disconnecting magnetic type, (when required), except for duct mounted reheat coils contractors shall be disconnecting mercury type.

G. Airflow Interlock: Diaphragm operated differential airflow pressure switch.

H. Leaving air temperature control for electric coils mounted in air handling units shall be 3 step control driven by a unit mounted modulating thermostat.

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 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 and as required by Section 01 91 00 GENERAL COMMISSIONING REQUIREMENTS 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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The United States Department of Veterans Affairs

VHA Boiler and Associated Plant Safety Device Testing Manual
Fifth Edition

By
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December 2018

PURPOSE

This document was prepared for use in training and conducting safety reviews for the United States Department of Veterans Affairs.

Fifth Edition, 2018 revision

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Table of Contents

1. INTRODUCTION

1.1 OBJECTIVE

This manual represents a minimum standard for boiler and associated plant safety device testing. The purpose of this manual is to support the development of an individual boiler and associated plant safety device testing program for your specific facility as required by the VA. The text presents a concise and thorough treatment of boiler safety as applied to automatically-fired gas and oil, heating and process boilers and boiler support equipment servicing healthcare facilities. The text includes a description of each boiler safety device, how it works, what happens if it doesn't work, what its purpose is, and how to test the device. The safety devices are organized by categories in four chapters: Water Level Control, Pressure Containment, Fuel Train Safety Devices, and Burner and Air Train Safety Devices. Appendix A provides detailed step by step procedures for testing every device covered for steam boilers and many of those devices required for hot water boilers. Devices not applicable to hot water boilers are noted in Appendix A. Appendix B contains 4 test procedures that are specific for hot water boilers. Appendices A and B can be used as a checklist and guide for safety testing and as a template for developing a site specific test procedure. It is important to understand that the VA directive calls for each facility to develop a written, site specific safety testing procedure. Some boilers will not include all of these devices as is explained in Appendix A.

The text does not replace existing standards. It succinctly states the main import of the standards. The final guide to safety should include all applicable standards. However, the testing envisioned in this text is generally more rigorous than current industrial practice or standards. In situations that may arise where adherence to this manual would adversely affect the operation of the boiler, special authority may be requested to deviate from the manual through the Director, OCAMES (10NAS).

1.2 BACKGROUND INFORMATION

One must understand that the use of the term "boiler" may refer to the system that includes the generation of steam, hot water, or hot oil. There are many safety devices such as level alarms, safety valves, relief valves, etc. that are found on the components involved in the distribution and use of steam. The safety checks are necessary and must be conducted on **<u>all devices in the system</u>** in order to ensure that the system is safe.

It is important that one has the manufacturer's manuals and wiring diagrams and on all equipment to be tested before beginning the tests described herein and have a customized testing procedure specific to the boiler plant.

1.3 REQUIREMENTS FOR SAFETY TESTING

1.3.1 Properly test and analyze each safety device to determine VA Compliance

There are three questions that the person conducting the safety test must be able to answer affirmatively for a safety device to be VA compliant. **<u>IN THE TEST PROCEDURES GIVEN IN APPENDICES A AND B, THIS SET OF QUESTIONS IS CALLED THE "3 QUESTION CRITERIA". IT IS SUCCINTLY STATED IN THE BOX ON THE NEXT PAGE.</u>**

If any of the three questions are not answered affirmatively for a safety device, the device in question FAILS to be VA compliant. If there is a failure of any safety device that can't be fixed immediately, the boiler must be removed from service or an Interim Safety Measure (ISM) developed, approved, and instituted until the repair is completed. In this situation the Medical Center Director must be notified of the situation.

THE 3 QUESTION CRITERIA

1. **Is the correct device installed?**
   - A device approved by the VA that meets all VA requirements and standards
   - The device is in the right location as defined by VA requirements and standards
   - The device is set up to accommodate testing
   - Any valve isolating the device is lockable only in open position
   - If the device is a switch, it must open when it actuates.
   - Any signal used in process control cannot be used as an input to a safety system.
   - Independent safety control includes the fact that the safety control must be located in an enclosure that contains no other type of control.
   - Any shunt on low water cutoffs (bypass switch) must be a non-latching device. No other shunts are allowed.
   - The use of a snubber, dampener, pneumatic accumulator or other such device to dampen the pressure provided to a safety switch or gage used in testing the switch is not VA compliant.

2. **Does the device activate at the proper set point that is in accordance with the criteria for the set point as defined herein and VA standards?**

3. **Does the device produce the proper result for its intended purpose (i.e. device must result in actions defined herein)?**

1.3.2 REQUIRED CERTIFICATIONS FOR EACH SAFETY DEVICE TEST REPORT

A VA compliant test report will contain the following certification on the first page following the cover page of the report.

I certify that I have properly tested all applicable safety devices listed in this report for boiler #______and its associated equipment and I certify that all of these tests confirm that every device tested "passed" as defined by the following question: Did the device fail or pass the 3 question criteria?

______________________	______________________	______________
PRINTED NAME	**SIGNATURE**	**DATE**

______________________	______________________
Position Title	**Company**

OR

I certify that I have properly tested all applicable safety devices listed in this report for boiler #_______ and its associated equipment and I certify that some of these tests failed as defined by the following question: Did the device fail or pass the 3 question criteria? More details of these failures are given in Appendix F (Comments on each individual test)

______________________	______________________	______________
PRINTED NAME	**SIGNATURE**	**DATE**

______________________	______________________
Position Title	**Company**

1.3.3 Confirming That All Devices Actually Function for Intended Purpose
In testing any safety device, it is paramount that the testing procedure verifies compliance with the three requirements listed above.

1.3.4 Lockable Valve Requirements
In order to facilitate testing of some types of safety devices, it is sometimes necessary to temporarily isolate the safety device and provide test ports by means of manual valves. However, these modifications cannot be allowed to increase risk by locking out a safety device during normal operation and must clearly indicate test and normal position. Any such manual valve that could isolate a safety device from its normal

operating circuit must be lockable and the lock must be lockable **only** in the correct operating position. It is most important that in normal operation the valve is actually locked.

1.3.5 Confirming That Jumpers Are Removed and Valves Properly Locked
In many cases in order to test a device, it will be necessary to either electrically jumper (bypass) a device or to valve out the device. The safety testing personnel should only carry a fixed number of jumpers and should make sure that at the end of a test that all jumpers being used are accounted for and that all lockable valves are locked in their correct position.

1.3.6 Adherence to Electrical Safety
The VA complies with the NFPA 70E Electrical Code. In executing the safety procedures described herein, it is sometimes necessary to open an electrical panel with a voltage sufficient to require various levels of protection. No personnel should perform such operations without being qualified with the proper training and gear. While this requirement will not be listed for each safety test, **it must be understood that all personnel must rigidly adhere to the requirements of NFPA 70E.**

1.4 NOMENCLATURE

AFOSV	Automatic Fuel Oil Shutoff Valves
ALWCO	Auxiliary Low Water Cutoff on steam boilers
ALWCOHW	Auxiliary Low Water Cutoff on Hot Water Boilers
APFGSOV	Automatic Pilot Fuel Gas Shutoff Valves
APFGSVV	Automatic Pilot Fuel Gas Solenoid Vent Valve
AMSOV	Atomizing Media Shut Off Valve
CAPI	Control Air Pressure Interlock
CAPS	Combustion Air Pressure Switch
DA	Deaerator
DAODS	Deaerator Overflow Drain System
DASV	Deaerator Safety Valve
ESPB	Emergency Stop/Panic Button
FDDWOPS	Forced Draft Damper Wide-Open Pre-Purge Proving Switch
FDMIS	Forced Draft Motor Interlock Switches
FGRDI	Flue Gas Recirculation Damper Interlock
AFGSOV	Automatic Fuel Gas Shutoff Valves and Solenoid Vent Valve
AFGSVV	Automatic Fuel Gas Shutoff Solenoid Vent Valve
FPI	Furnace Pressure Interlock
FS	Flow Switch on Hot Water Boilers
FSMFO	Flame Scanner-for main flame out
FSNSIS	Flame Scanner Not Sensing Igniter Spark
HFGPCS	High Fuel Gas Pressure Cutoff Switch
HFOPCS	High Fuel Oil Pressure Cutoff Switch
HWAB	High Water Alarm on Boiler
HWACT	High Water Alarm on Condensate Tank
HWTS	High Water Temperature Switch on Hot Water Boiler
HWADT	High Water Alarm on Deaerator Tank
IT	Igniter Timing
LAMDPS	Low Atomizing Media Differential Pressure Switch

LAMFS	Low Atomizing Media Flow Switch
LAMPS	Low Atomizing Media Pressure Switch
LFGOLI	Low Flue Gas Oxygen Level Interlock
LFGPCS	Low Fuel Gas Pressure Cutoff Switch
LFOPCS	Low Fuel Oil Pressure Cutoff Switch
LFPS	Low-Fire Proving Switch
LPFGPCS	Low Pilot Fuel Gas Pressure Cutoff Switch
LRVE	Liquid Relief Valve on Economizer
LRVE\HW	Liquid Relief Valve on Hot Water Boiler
LRVOPS	Liquid Relief Valve on Oil Pump Set
LWA	Low Water Alarm
LWACT	Low Water Alarm on Condensate Tank
LWADT	Low Water Alarm on Deaerator Tank
LWCO	Low Water Cutoff on Steam Boiler
LWCOHW	Low Water Cutoff on Hot Water Boiler
MFIT	Main Flame Ignition Timing
MV	Manual Valve
NRBSPLS	Non-Recycle Boiler Steam Pressure Limit Switch
OADA	Outside Air Damper Alarm
OBPS	Oil Burner Position Switch
OSDPI	Outlet Stack Damper Position Interlock Switch
PAPS	Purge Airflow Proving Switch
POC_AFOSV	Proof of Closure on Automatic Fuel Oil Shutoff Valves
POC-AFGSOV	Proof of Closure on Automatic Fuel Shutoff Valves
PPT	Pre-Purge and Post-Purge Timing
PRV	Pressure Reducing Valve
RBSPLS	Recycle Boiler Steam Pressure Limit Switch
SVB	Steam Safety Valves on Boiler
SVFPRV	Safety Valve Following PRV
TP	Test Port

1.5 PREPARATION OF SYSTEM FOR SAFETY TESTING

The normal boiler installation does not generally allow easy access and control for testing. Safety testing is an ongoing activity for safe boiler plant operation. In this section a discussion is given of system design considerations that will allow easy testing. The discussion is organized around classes of different safety devices. For detailed drawings illustrating an appropriate test setup for each device, refer to the safety testing procedures given in the Appendices A and B. A list of test equipment that is satisfactory for conducting the safety tests is given in Appendix E. The list is an example but many other comparable instruments could be utilized.

1.5.1 Setup for testing a Steam Safety Valve Following a PRV

In order to test a safety valve following a PRV, a manual isolation valve must be installed downstream of the safety valve so that the valve can be tested without raising the pressure on the system downstream of the valve. (See Figure 1.1)

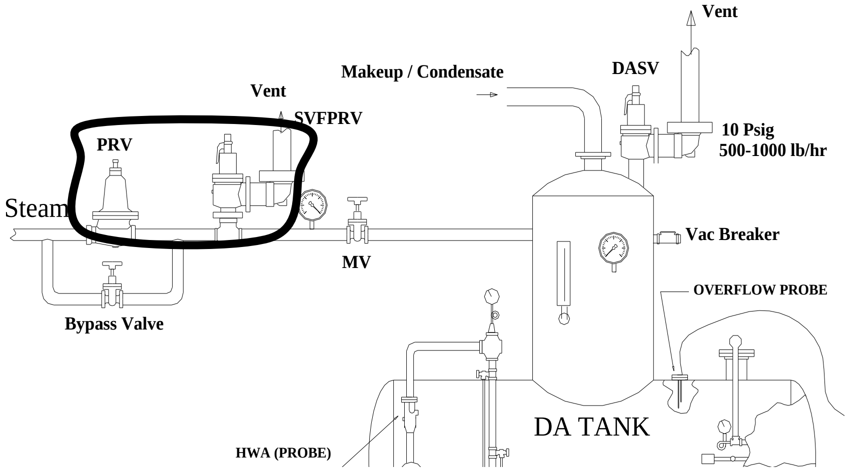


Figure 1.1 Example of Steam Safety Valve Following a PRV

1.5.2 Setup for testing a Combustion Air Pressure Switch, Purge Air Proving Switch, Furnace Pressure Interlock, Control Air Pressure Interlock, High Fuel Gas Pressure Cutoff Switch, High Fuel Oil Pressure Cutoff Switch, Low Fuel Gas Pressure Cutoff Switch, and Low Fuel Oil Pressure Cutoff Switch.

In order to test these switches, it is necessary to be able to temporarily isolate these switches from the normal pressure source and either increase or decrease the pressure applied to the switch using the test port in order to determine the switch trip point. At the same time the piping must be such that the actual pressure that the switch senses can also be measured. The arrangement is pictorially shown in Figures 1.2 for the case of a Combustion Air Pressure Switch. The other switches listed above should be set up in a similar manner as indicated in the respective test procedures in Appendix A.

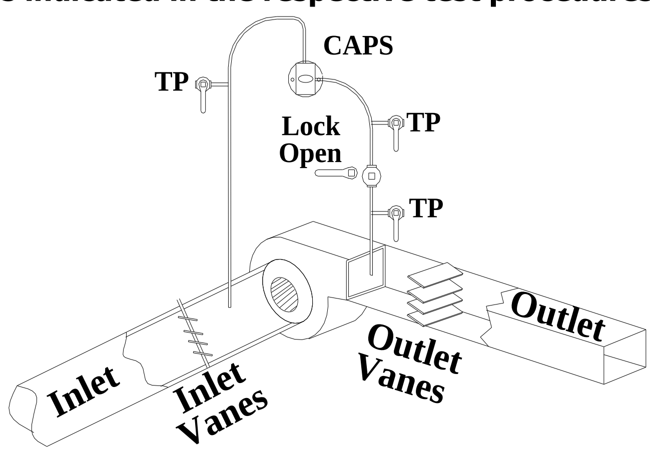


Figure 1.2 Combustion Air Pressure Switch (CAPS) Setup

1.5.3 Setup for Leak Checking Oil and Gas Block Valves and Gas Bleed Vent Valve

In order to easily test for leaks in the block valves, a test port (TP) and calibrated pressure gage must be available both in the line between the valves and downstream of the second valve. Also in the case of gas, a lockable manual valve downstream of the solenoid bleed vent valve is required. A port and pressure gage in the line between the solenoid valve and lockable manual valve is also needed as shown in Figure 1.3. Note, there are two test ports (TP) for determining normal operating pressures and one test port (TP) for testing the automatic fuel gas vent valve for leaks. This arrangement is schematically shown for natural gas in Figure 1.3. The arrangement for testing the automatic fuel oil valves is the same with the exception the vent line is absent with its attendant test arrangement as shown in the test procedure for oil leaks in Appendix A. (Note that some boiler manufacturers do include a liquid relief valve between the two automatic fuel shut off valves. If this relief valve is included it must be tested.)

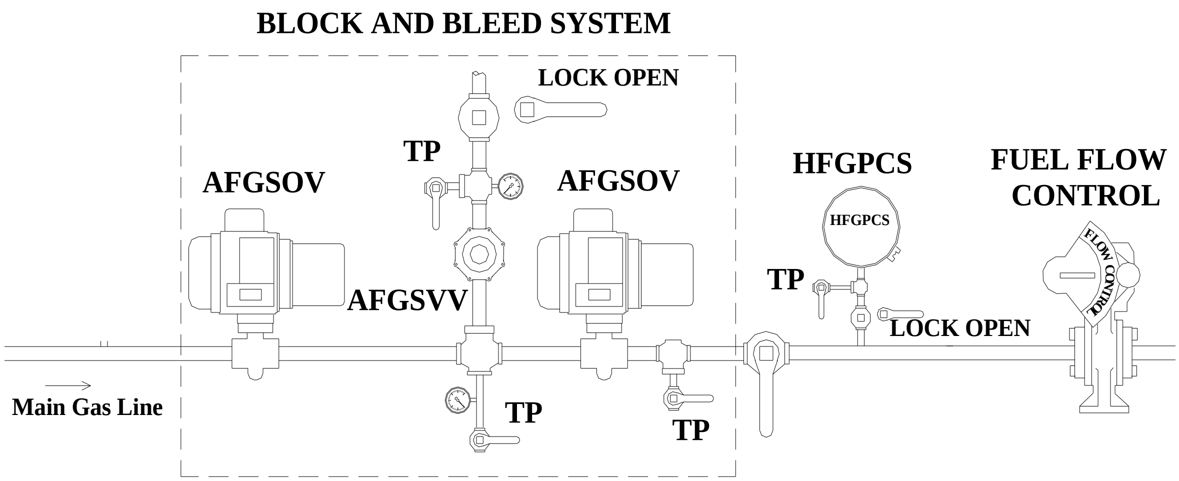


Figure 1.3 Test setup for leak testing the two Automatic Fuel Gas Shut Off Valves and the Automatic Fuel Gas Vent Valve

1.5.4 Setup for Checking Dangerous Gas Detection System for the Building

Sample gas with a level of CO and combustibles equal to the sensor set points should be available with a means to supply the gas to the sensor per the manufacturers test procedures.

1.5.5 Setup for Checking the Deaerator Overflow System and Oil Liquid Relief Valve

A sight glass with turbine wheel should be installed downstream of the valve in order to visually confirm that flow exists. The oil liquid relief valve also requires a pressure gage at the pump discharge.

1.5.6 Setup for Checking Proof of Closure Switches, Low Fire Proving Switches, Force Draft Damper Vane Interlock, Outlet Stack Damper Interlock, Recycle Steam Pressure Switch, Non-recycle Pressure Switch, and Recirculation Damper Interlock

It is necessary to electrically isolate or jumper these switches for testing. Although not necessary, it may be convenient to have the two electrical leads from each of these switches wired into an electrical control panel where it is easy to either remove one lead from the terminal block to isolate the switch or to jumper across the two leads to simulate a switch in the closed position.

1.5.7 Setup for Low Water Cutoffs

A low water cutoff can be treated in the same way as those switches in section 1.5.6. It is more convenient to have independent, non-latching shunt test switches (Momentary bypass switch) for isolating the two low water cutoffs for steam boilers and hot water boilers that are fitted with two low water cutoffs. This shunt test switch is required for each low water cutoff by VA standards for boilers fitted with two low water cutoffs.

1.5.8 Setup for Hydrostatic Testing

In order to hydrostatically test any device, it is necessary that valves are available to isolate the device, a test port is available to apply the test pressure, and a pressure gage is available to monitor the pressure in the device (See Figure 1.4 as an example). All devices that could be damaged by the test pressure must be removed or properly isolated prior to conducting the hydrostatic testing. If it is desired to use a hydrostatic test pressure above the pressure at which the safety valve or liquid relief valve opens, it is necessary to remove the valves and blank off the opening.

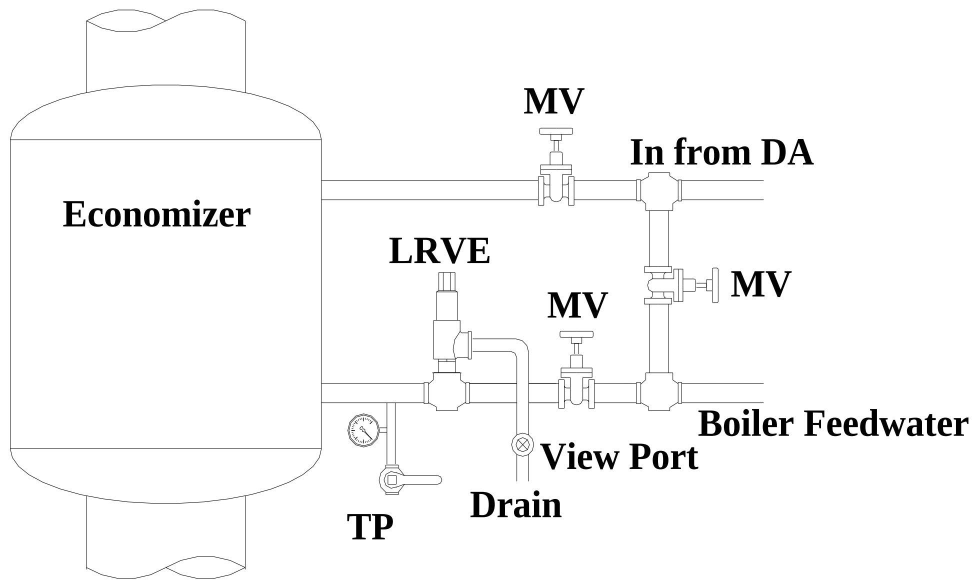


Figure 1.4 Hydro Testing

2 WATER LEVEL CONTROL

2.1 LOW WATER CUTOFFS

2.1.1 Description
A low water cutoff is a device that causes the automatic fuel safety shutoff valves to close if the water level in the boiler drops below a pre-set safe level. Low water causes about 50 percent of all boiler incidents. Low water can cause the boiler to overheat which could lead to the failure of the pressure vessel with enormous potential damage (explosion). Two low-water cutoffs are required for steam boilers while hot water boilers are required to have at least one low water cutoff. Low-water cutoffs operate either on a "float" system or electrode system (probe) for steam boilers. Any low water cutoff for hot water boilers must be a probe. In the float system there is a pipe connection to the boiler high and low connection points. Between these connection points there is a vertical section containing a volume sufficient to house the float. If the water level falls below a prescribed level, the falling float will cause a switch to actuate causing the automatic fuel valves to close. (See Figure 2.1)

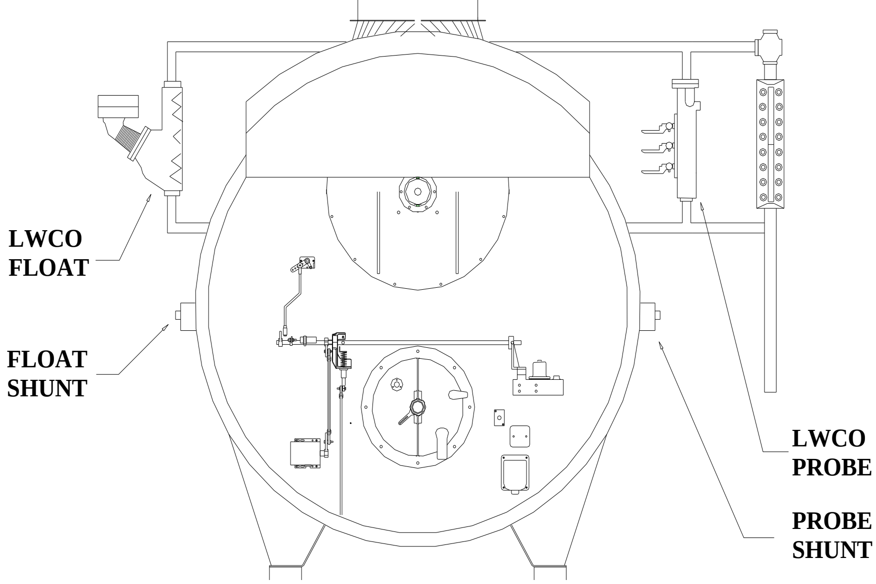


Figure 2.1 Low Water Cutoff

In the electrode system, there is a similar piping arrangement as in the float system. Probes extend vertically downward into the vertical pipe connecting the piping to the high and low boiler connection points or for hot water boilers directly into the boiler. The electrodes are located at the bottom of the probe and are used to measure the conductivity of the media in which the electrodes are immersed. The conductivity of water is much higher than steam. Hence, if the water level drops below the probe, a drastic change in conductivity occurs. This change is used in an electrical circuit to cause the automatic fuel shut-off valves to close. Most safety codes require at least one float system be included to protect against low water for steam boilers. This is shown in Figure 2.1. The VA requires one float and one probe for steam boilers. True redundancy requires that the low water cutoffs be in two separate piping arrangements as shown. Placing both low water cutoffs in a single piping arrangement could lead to a situation in which blockage in the piping arrangement renders both level control safety devices useless.

Some low-water cutoffs are provided with non-latching "shunt" test switches by which the low water cutoff switch is bypassed. A non-latching shunt test switch means that the test switch must be manually held open in order to bypass the low water cutoff switch. The VA requires individual shunt test switches for both low water cutoffs for steam boilers. Operators can use the shunt test switch in "testing" each low-water cutoff by simply by-passing one low water cutoff by holding in the other low water cutoff shunt test switch and allowing the active low-water cutoff to shut down the boiler. This procedure is then repeated for the other low water cutoff. Operators electrically check the low water cutoff using this method.

A boiler control system should never allow the boiler to automatically restart after a low-water cutoff has actuated to stop boiler operation and all trip points must occur with water clearly in the sight glass.

A detailed step by step test procedure is given in Appendix A for steam boilers and Appendix B for hot water boilers.

2.1.2 Consequences of Low Water Cutoff Failure

If the low water cutoffs both fail, the boiler would then be fired with no water in the boiler. This will cause the metal temperatures to rise rapidly and the metal strength to be significantly decreased. In fire tube boilers the main Morrison tube typically collapses which could allow steam onto the boiler fireside. The steam pressure has been known to blow the ends out of the boiler through concrete block walls a distance of hundreds of feet. Similar catastrophes could occur in water tube boilers.

2.1.3 Testing a Low Water Cutoff

Low-water cutoffs must be tested in a mode in which they fail. Testing is basically done by allowing the water level to lower in a "slow drain". In order to be in a realistic mode, one must not follow a procedure that actuates the cutoff by rapidly blowing off a volume of water from the water column containing the switch. This is very important in testing a float type cutoff. The rate of decrease in water level is required to be a maximum of 1 inch/minute.

A detailed step by step test procedure is given in Appendix A for steam boilers and Appendix B for hot water boilers.

2.2 LOW WATER ALARM

2.2.1 Description

The low water alarm provides audible and visual warnings that the water level is approaching a dangerously low level. These alarms are based either on a conductivity probe or float as described in the previous section. These alarms are required on the steam boiler, deaerator, and condensate receiver tanks. On the boiler, the low water alarm must be set to activate before either of the low water level cutoff switches shuts off the boiler. On the deaerator and condensate receiver tanks, the alarm is the only indication of a low water problem. On these devices the setting should be above 1/3rd of the tank diameter and with visible water in the sight glass. The alarm should not be set so high that it causes excessive alarm activation. Of course lack of water in the deaerator or condensate receiver will quickly result in loss of water to the boiler with the problems described in the section of low water level control.

2.2.2 Consequence of Water Level Alarm Failure

Low water in a condensate or deaerator tank is a precursor to low water failure in a steam boiler with the problems described above. There is also the hazard of damage to a condensate transfer or boiler feed pump from running dry. A low water alarm on a boiler is a warning to operators of an impending potential problem of a "boil out" of water.

2.2.3 Testing Low Water Alarms

This alarm is tested by causing a drop in water level in the vessel being tested. The alarm should activate at the desired set point (the set point must be above the level at which the first low water cutout activates, at a level allowing operators time to restore the proper level, and visible in the appropriate sight glass).

A step by step procedure is given in Appendix A for three situations: steam boilers, deaerators, and condensate tanks.

2.3 HIGH WATER ALARM

2.3.1 Description

A high water alarm is required on a steam boiler, deaerator, and condensate tanks to aid in preventing overfilling. Due to the failure rate of float type devices used for this purpose, **high water alarms must always be conductivity probe type devices for VA compliance.**

2.3.2 Consequence of High Water Alarm Failure

High water in a condensate tank could lead to backup of condensate in condensate lines. High water in a deaerator will result in poor deaeration but also leads to violent shaking of the vessel. High water in a steam boiler could result in pushing liquid into the steam line. Slugs of water in the steam system can move at high velocity due to the motive force of steam causing water hammer. Water hammer can cause valves and other fittings to explode and steam piping to rupture. Death and injury from these events is a regular occurrence. This same effect could produce high water levels in the steam supply to a steam powered appliance connected to the system with detrimental effects on the process.

2.3.3 Testing the High Water Alarm

The high water alarm must be tested off-line. Slowly fill the vessel with water, observe the water level in the sight glass, and note the point at which the alarm sounds. Be careful not to overfill the system, above the level at which the alarm should actuate.

A step by step procedure is given in Appendix A for three situations: steam boilers, deaerators, and condensate tanks.

2.4 OVERFLOW DRAIN SYSTEM

2.4.1 Description

Deaerator tanks and condensate storage tanks have overflow systems to prevent overfilling. The deaerator overflow is shown in Figure 2.2. The overflow system on the condensate tank also helps guarantee that the condensate tank remains at atmospheric pressure and consists of a drain line connected to the vessel. The drain line from a deaerator includes a normally closed device that opens if the water level is too high and allows water to drain either to sewer or into the condensate tank. The VA requires that the condensate tank be a pressure vessel with the same basic requirements as the deaerator if the deaerator overflows into the condensate tank. Two different types of overflow control valve systems are allowed for the deaerator.

- An electronic valve which is operated by a conductivity probe indicating that water level is too high.
- An electronic valve which is operated by a differential pressure cell indicating that water level is too high.

The signal used to control makeup water into the deaerator must not be used to control the overflow valve.

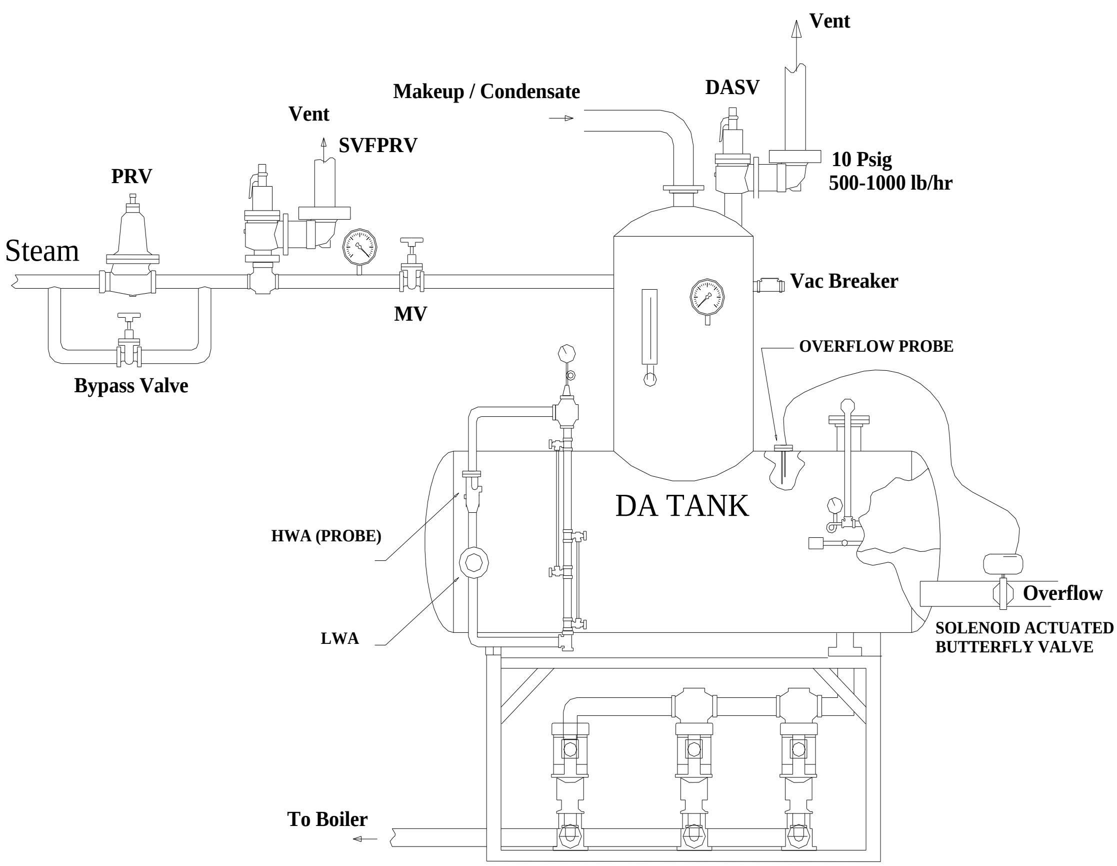


Figure 2.2 Overflow Drain System

2.4.2 Consequence of Overflow Drain Failure

The consequence of an overflow drain failure is the same as that discussed in section 2.3.2.

2.4.3 Testing the Overflow Drain System on a Deaerator

The purpose of the test is to determine if the system is capable of draining water from the deaerator at a rate equal to or greater than the maximum potential supply of water to the deaerator. The system can be tested with the deaerator out of service (steam valved out and feedwater pumps off). To test the drain system, fill the deaerator with water at a rate equivalent to the maximum rate that could possibly be supplied to the deaerator. Observe the water level in the sight glass. Use the sight glass to confirm that the drain system is capable of maintaining the water level at the drain level.

A step by step procedure is given in Appendix A.

3 PRESSURE CONTAINMENT

3.1 STEAM SAFETY VALVES

3.1.1 Description

The steam safety valves are connected to a steam boiler, steam line, or other device that must be protected from over-pressure. Each steam safety valve discharges into a drip pan ell which discharges through a slip joint into an oversized vent pipe that extends to outside the building. By utilizing drip pan ells, there is no direct connection between the vent pipe and the safety valve so that there is no stress imposed on the safety valve from the thermal expansion of the vent pipe. Additionally any liquid that accumulates due to condensation, drains and does not impact relief capacity. Correct installation includes leaving about a one-inch gap between the drip pan and the bottom of the vent pipe. Steam safety valves must be present on a steam boiler, deaerator, any pressurized condensate receiver, and at all points in steam lines just downstream of any pressure-reducing valves. Each safety valve must have a dedicated separate vent line and drain (See Figure 3.1). Properly designed redundant safety systems for this extremely important safety device allow the system to prevent a boiler explosion even if one of the safety valves and/or vent system fails. All steam safety valves must be lifted by steam pressure.

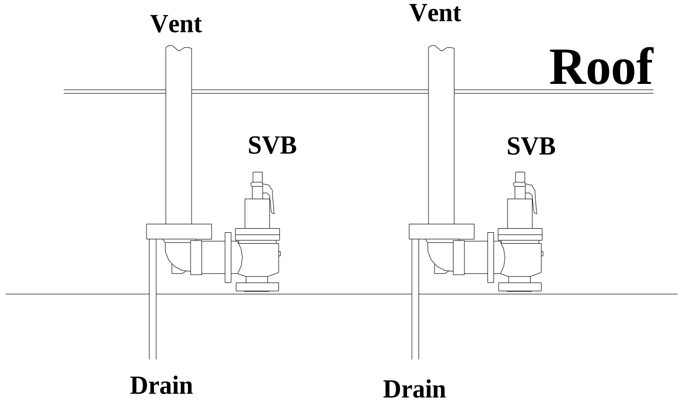


Figure 3.1 Boiler Safety Valves

3.1.2 Consequences of a Steam Safety Valve Failure

Steam safety valves are the last line of defense against the over-pressurization of a steam boiler or steam system components. If these valves fail along with all the other measures designed to prevent over-pressurization, a violent explosion could occur. Such an explosion could damage buildings and injure or kill people within several hundred feet of the boiler or system component.

3.1.3 Checking a Steam Safety Valve

The steam safety valves are checked by closing the main steam stop and allowing pressure to build up (The recycle and non-recycle switches are bypassed) until the safety lifts. By continuing firing the boiler in high fire all the safeties should be able to be tested.

Some authorities recommend doing all steam safety valve testing on a test stand. However, there is a chance that the valves could be mixed up or damaged in installation so that this test method is not as reliable as testing the valves in situ and is not allowed by the VA to satisfy compliance. Also some authorities check a steam safety valve by lifting the handle by hand. This test does not confirm that the valve opens at its proper setting. It does confirm that the valve can vent steam (is not blocked). Lifting of a safety valve by hand does not meet the VA requirement for compliance. Gagging of a safety valve for test purposes is prohibited and should never be used.

A detailed test procedure is given in Appendix A for three situations: boilers, deaerators, and piping following a PRV station**.**

3.2 RELIEF VALVES

3.2.1 Description

Relief valves are spring-loaded valves that open if the liquid pressure in the system that they control increases above a pre-set limit. They are similar to safety valves with the exception that they do not exhibit "popping" action or blowdown. (Relief valves do not incorporate the "huddling" chamber found on safety valves). These valves are connected directly to an exhaust pipe that conveys the fluid to the building exterior or storage tank. Three important pieces of equipment requiring relief valves in boiler applications are economizers, hot water boilers, and oil pump sets.

3.2.2 Consequences of a Relief Valve Failure

Failure of a relief valve could lead to a pressure vessel explosion with serious consequences. Failure could also lead to equipment damage due to overheating-e.g. in operation of an oil pump.

3.2.3 Checking a Relief Valve

A testing procedure for the relief valve on an oil pump set and economizer is given in Appendix A. A test procedure for hot water boilers is given in Appendix B.

3.3 HIGH STEAM PRESSURE LIMIT SWITCHES

3.3.1 Description

A steam boiler should be fitted with two, high-steam-pressure-limit switches (HSPLS). Both switches have the function of causing the two automatic fuel shut off valves to close if a preset pressure limit is exceeded. One switch may be a recycle switch meaning that once the pressure falls below the set point pressure the boiler will automatically restart. The other switch must be a non-recycle switch meaning that it must be manually reset after a pressure excursion above its limit. The pressure setting on the non-recycle switch should be slightly higher than the setting on the recycle switch but lower than the lowest lift pressure for the safety valves. The required differences in the settings described above should be sufficient to allow the boiler to operate without excessive nuisance trips or blowing of safety valves and are enumerated in Appendix A.

3.3.2 Consequences of High Steam Pressure Limit Switch Failure

If both HSPLS switches were to fail, the safety valve becomes the last line of defense against a pressure vessel explosion. A tendency of boiler operators is to not worry about the performance of the HSPLS (especially the non-recycle one) because the safety valve is still available to save the operation. This thinking represents the "slippery slope" in safety because true safety relies on redundant measures. In looking at accidents in industry, one can almost always find several unsafe factors that led to the particular accident. Ignoring the first warning escalates the risk.

3.3.3 Checking High Steam Pressure Limit Switches

These switches are checked by closing the main steam valve and firing the boiler until the pressure is elevated to a point that the safety activates. The recycle safety must be jumped in order to test the non-recycle switch.

These tests are described in Appendix A.

3.4 BOILER HYDROSTATIC TESTING

3.4.1 Description

A hydrostatic test is performed on a boiler, deaerator, pressurized condensate receiver and economizer to determine if it is capable of withstanding the potential operating pressure. It is very important to understand that any leak is a sign of weakness in the vessel and should be thoroughly inspected by a professional and properly repaired before the vessel is put back into operation. (These leaks could represent small cracks or metal thinning/corrosion/etc. that is not discernable to the eye).

3.4.2 Consequences of Failure to Hydrostatic Test

If weak spots are present and the vessel is operated, a significant chance exists that a pressure vessel explosion could occur with tremendous loss of property and life. Failure to perform a proper hydrostatic test would allow a weakened vessel to be operated with the associated dangers of such operation.

3.4.3 Performing a Hydrostatic Test

To perform a hydrostatic test, fill the vessel completely full of water below 200 F. Remove and/or isolate all safety and relief valves. Close all supply and discharge lines. The boiler must be completely locked and tagged out from all energy sources following OSHA requirements and the fireside opened for inspection. The hydrostatic pressure for the test should be 1.5 times working pressure applied for several hours. The dry side must be checked for any sign of leaks. Any leaks must be professionally evaluated in terms of whether the vessel can be operated safely without repair.

In applying the hydrostatic pressure, care must be exercised not to overpressure the vessel. If the vessel were pressurized above its elastic limit, the vessel would not be fit for further use and should be scrapped!

4 FUEL TRAIN SAFETY DEVICES

4.1 LOW PRESSURE FUEL CUTOFF SWITCH

4.1.1 Description

The low-pressure fuel cutoff switch causes the automatic fuel shutoff valves to close if the fuel pressure is below the lower limit for safe operation. Low pressure fuel cutoff switches are found on the main gas line, main oil line, and pilot gas line. The switch in all three of these applications senses the supply fuel pressure after the pressure regulating valve and upstream of any fuel control valve (See Figure 4.1). For the main oil and gas supply lines, the switch is in continuous operation once the boiler is in the run mode. For the pilot gas supply, the switch operates continuously while the pilot flame is on. A common operational problem with a low pressure cutoff switch occurs due to the PRV allowing a "dip" in fuel pressure on startup. Some facilities have installed a snubber or accumulator between the fuel line and switch to prevent the switch from activating. Snubbers and accumulators are not allowed by VA requirements and standards.

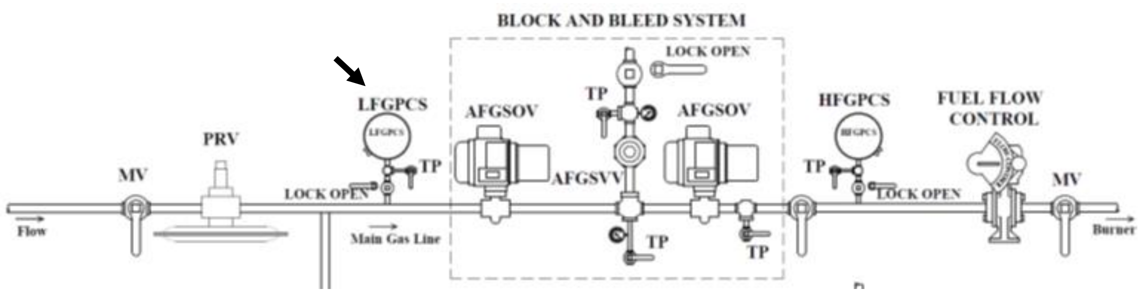


Figure 4.1 Low Pressure Fuel Cutoff

4.1.2 Consequences of Low Pressure Fuel Cutoff Switch Failure

Low fuel pressure can result in unstable burning or flameout conditions. When fuel pressure returns to normal, the combustion chamber can overfill with fuel before igniting. This can easily result in combustion explosions that are violent enough to blow the "ends" of the boiler and even through surrounding structures. Extensive property damage, injury, and even death can result.

4.1.3 Checking the Low Pressure Fuel Cutoff Switch

This switch is checked by isolating the switch and slowly venting gas until the switch activates. A step by step test procedure for the low pressure fuel cut out switch for the main gas and main oil supply systems as well as the pilot gas system is given in Appendix A.

4.2 HIGH PRESSURE FUEL GAS CUTOFF SWITCH

4.2.1 Description

The high fuel gas pressure cutoff switch is used to cause the automatic fuel shutoff valves to close if fuel pressure is above a given higher limit for safe operation. These switches are used for both the main gas and main oil fuel supply systems (See Figure 4.2). In both applications the switch should be located after the pressure regulating valve and upstream of the fuel control valve. The switch is in continuous operation once the boiler is in the run mode.

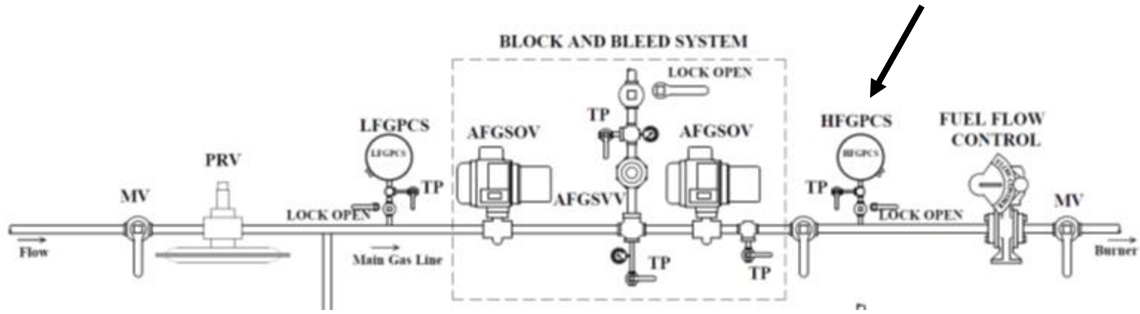


Figure 4.2 High Pressure Fuel Cutoff

4.2.2 Consequences of High Pressure Fuel Cutoff Switch Failure

High fuel pressure can cause unstable flame conditions but more importantly it can result in over-firing the boiler. Over-firing can damage burner/boiler materials to the point of meltdown and explosion. The generation of steam can be so intense that a pressure vessel explosion can occur. High fuel pressure can easily occur if a pressure regulator and high-pressure cutoff switch were to fail.

4.2.3 Checking the High Pressure Fuel Cutoff Switch

The switch is checked by isolating the switch and using a hand pump or equivalent device (see Appendix E for equipment list) to raise the pressure until the switch trips out the boiler. A step by step test procedure for the high pressure fuel cut out switch for the main gas and main oil supply systems is given in Appendix A.

4.3 VENTING BETWEEN AUTOMATIC GAS SHUTOFF VALVES

4.3.1 Description

The volume between the automatic fuel gas shutoff valves should be vented to the atmosphere with a system as shown in Figure 4.3 for both the main gas and pilot line automatic shut off valves. While the boiler is running the solenoid valve is shut and gas flows through the two automatic shutoff valves to the burner. When the fuel shut-off valves close, the solenoid valve opens and vents any residual gas in the space between the valve and any leakage of gas through the first automatic shutoff valve.

The purpose of the vent system is to ensure that even if the first automatic shutoff valve leaks, the gas is vented rather than allowed to move through the second automatic fuel-shutoff valve and then into boiler. The vent line must be vented to the atmosphere outside of the building.

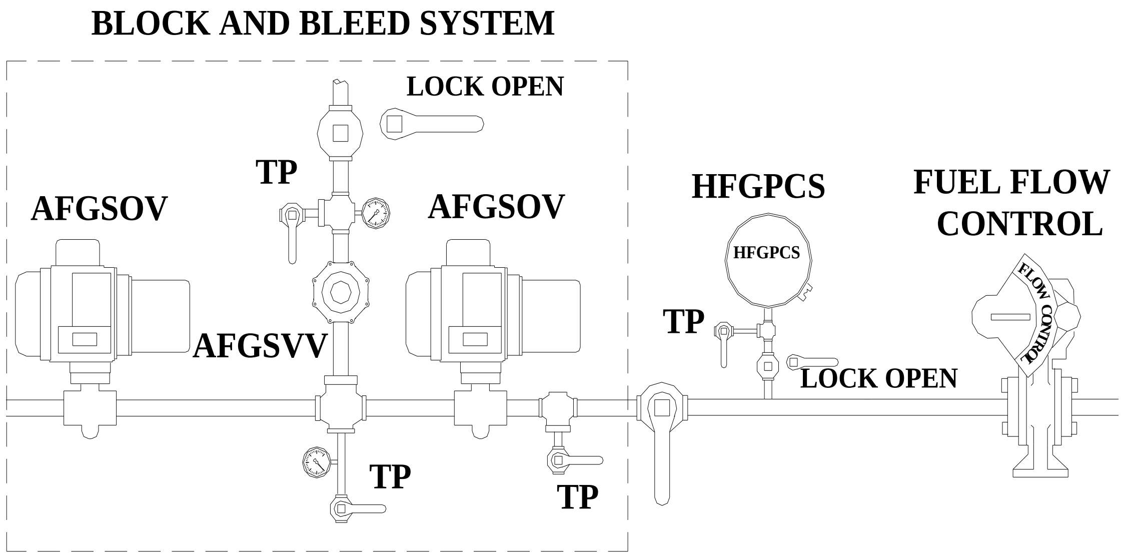


Figure 4.3 Gas Train Vent Valve

4.3.2 Consequences of a Failed Vent Valve
Fuel leaks into the boiler are obviously dangerous because if both automatic shut off valves leak, gas would fill the boiler furnace while the boiler is off. Fuel mixed with air is a potentially explosive mixture that with any source of ignition could result in disaster. On ignition if purging did not adequately vent this gas, a tremendous explosion would result when lighting the burner. This combustion explosion could easily wipe out all property and personnel within several hundred feet of the boiler.

4.3.3 Testing the Gas Train Vent Valve (solenoid valve)
Testing of the vent system includes doing a bubble test with the boiler running by attaching a tube to the test port downstream of the AFGSVV as shown in Figure 4.3 and letting the other tube end be slightly immersed in water with the manual valve above the AFGSVV closed. The other test is to see if the pressure between the two automatic shut off valves goes to zero when the boiler stops running and the manual valve is open.

A detailed step by step procedure to check all these aspects of the vent valve are given in Appendix A.

4.4 LEAK TEST OF AUTOMATIC FUEL SHUT OFF VALVES

4.4.1 Description
A block and bleed system is provided as discussed in section 4.3 to prevent fuel from entering and potentially collecting in the boiler while the boiler is off. This system is used on the main oil and gas supply lines to the burner as well as the pilot gas supply. (On the main oil supply line a vent is not required. However, some manufacturers do use a vent and if one is provided, it must be equipped for testing and must be tested.) The two automatic shut off valves used in either case are the means by which the boiler is automatically shut down in case any operating limit is not satisfied. It is essential that these valves do not leak when closed. For both oil and gas, NFPA code requires two automatic shut off valves.

4.4.2 Consequences of Leaking Automatic Shut Off Valves

If both automatic fuel shut off valves leak and the vent system does not function (in the case of gas), fuel would be introduced into the burner and into the boiler furnace while the boiler is off. This fuel would produce a combustible mixture in the boiler. Fuel leaks into the boiler are obviously dangerous because it allows the presence of a combustible air-fuel mixture that could explode when the fuel is ignited on startup. This combustion explosion could easily wipe out all property and personnel within several hundred feet of the boiler.

4.4.3 Testing the Automatic Fuel Shut Off Valves for Leaks

The testing for leaks can be done when the boiler is off. The test procedure for natural gas is measuring for a leak with a "bubble test". This method involves connecting a tube to a confined space downstream of the valve being tested with positive pressure on the upstream side of the valve. The tube is placed approximately 1/16th of an inch below a water surface in order to have negligible back pressure. Any leak will show up as a bubble generated in the water at the tube exit. For oil a test port can be provided to visually observe whether oil drains from the test port.

A step by step procedure is given in Appendix A for both oil and gas.

4.5 OIL LOW ATOMIZING MEDIA PRESSURE AND DIFFERENTIAL PRESSURE/FLOW SWITCHES

4.5.1 Description

An atomizing fluid (compressed air or steam) is usually used to aid in the combustion of the oil fuel (See Figure 4.4). A safety switch is required that shuts the boiler off in case of low atomizing media pressure. This switch measures pressure in the atomizing fluid line immediately after the pressure regulating system and causes the automatic fuel control valves to close if the atomizing pressure falls below its set point. If there is a differential pressure regulator, the sensor must be located upstream of that regulator.

In some cases where air is used to atomize, no atomizing media differential pressure switch is used. For this case only the low atomizing media pressure switch described above is needed. For all other cases, a second switch is needed to help ensure that atomizing media is flowing at a sufficient rate into the burner. For the case in which the atomizing media pressure at the burner is greater than the oil pressure for all firing rates, a differential pressure switch is needed. For the case where the atomizing media is less than oil pressure at some firing rates ("crossover"), a flow switch is required by the VA. The differential pressure switch must be located as shown in the figure. The flow switch must be in the atomizing media line before it enters the burner.

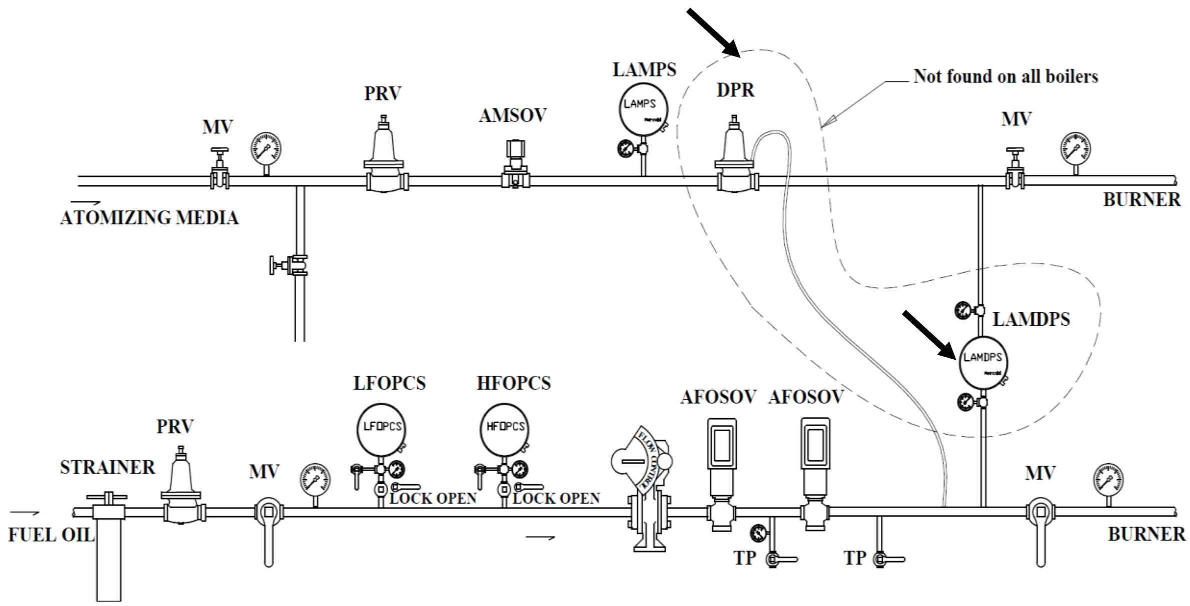


Figure 4.4 Low Atomizing Media and Differential Pressure Switches (Note Flow switch not shown)

4.5.2 Consequences of Low Atomizing Media Pressure, Inadequate Atomizing Media Differential Pressure or Inadequate Atomizing Media Flow

Low atomizing media pressure, low atomizing media differential pressure or low atomizing media flow could cause poor combustion leading to the production of carbon monoxide, flame instability, and possible combustion explosions leading to serious loss of property and injury/death.

4.5.3 Testing the Oil Low Atomizing Media Pressure Switch

The set point on the oil low atomizing pressure switch must not allow the atomizing media pressure to fall below 80% of the regulated pressure upstream of the switch testing is accomplished on-line by slowly lowering the oil atomizing media pressure and observing that the switch operates at the correct set point. If a low atomizing media flow switch is required, the testing is done on line by slowly closing the manual valve in the atomizing media line and observing the atomizing media pressure at point that the switch shuts off the boiler. The switch must shut off the boiler at a atomizing media pressure lower than 80% of the regulated pressure up stream of the switch.

4.5.4. Testing the Low Atomizing Media Differential Pressure Switch

The set point on the oil low atomizing media differential pressure switch must not allow the atomizing media differential pressure to fall below 80% of the minimum differential pressure seen by the switch from low fire to high fire. Testing is accomplished on-line at low fire by slowly closing the manual valve in the atomizing media line upstream of the low atomizing media differential pressure switch and observing the differential pressure at which the switch closes.

4.5.5. Testing the Low Atomizing Media Flow Switch

The set point on the oil low atomizing media flow switch must not allow the atomizing media flow to fall below 80% of the minimum differential pressure across the flow switch seen by the switch from low fire to high fire. Testing is accomplished on-line at low fire by slowly closing the manual valve in the atomizing media line upstream of the flow switch and observing the differential pressure at which the switch closes.
A step by step procedure for all these switches is given in Appendix A.

4.6 AUTOMATIC FUEL SHUTOFF VALVE PROOF OF CLOSURE SWITCH

4.6.1 Description

The function of an automatic fuel shutoff valve is absolutely essential. All safety devices that require fuel shutdown rely on the two automatic fuel shutoff valves to perform this task. Proof of Closure switches must be present in both automatic shut off valves. Both oil and gas automatic shut off valves require proof of closure switches. The switches in the two valves should be wired in series so that an indicated failure in either valve will prevent the boiler from starting. The proof of closure switch is an integral part of the automatic fuel shutoff valve. It has a simple function to guarantee that the automatic fuel shutoff valve is closed before allowing the boiler to go through the burner startup sequence. If the automatic fuel shutoff valve is not closed, the proof of closure switch will be open, breaking the circuit and not allowing the burner to start. The proof of closure switch is active only during the startup sequence.

4.6.2 Consequences of a Failed Proof of Closure Switch

If either proof of closure switch fails, the switch could "stick" closed even with the valve open. This malfunction would present a false signal to the burner management system indicating that the valve is closed when it might not be closed. This malfunction could allow the fuel to be ignited with a large quantity of fuel in the furnace. Under this scenario, a combustion explosion would occur. The result could be a tremendous loss of property and death as well as physical harm to personnel within in the boiler area.

4.6.3 Testing the Automatic Fuel Shutoff Valve (Proof of Closure) Switch

The proof of closure switch for the gas valves is tested by simultaneously looking at pressure downstream of the valve and the resistance across the switch that is isolated during the light off sequence. The resistance should change from a zero reading to an infinite reading before pressure is observed.

A detailed step by step procedure to testing the proof of closure switches is given in Appendix A.

5 BURNER AND AIR TRAIN SAFETY DEVICES

5.1 THE FLAME SCANNER

5.1.1 Description
A flame scanner is a device that continually monitors the flame to determine whether a flame is present in the combustion chamber. If the flame is extinguished for any reason, the scanner causes the two automatic fuel shutoff valves to close.

Modern flame scanners work by converting either the ultraviolet (UV) or infrared (IR) portion of the thermal radiation produced by the flame to an electrical signal. The UV scanner has some disadvantage in that it can sometimes see the igniter spark as a flame. The IR scanner has a disadvantage in that it can mistake glowing refractory for a flame. A self-checking UV scanner is required to be in compliance with the VA specifications. The "self-checking" feature detects a scanner failure and immediately shuts down the burner." The strength of the electrical scanner signal is then the indication as to whether an adequate flame is present.

5.1.2 Consequences of a Failed Flame Scanner
If the flame scanner allows fuel to be supplied to the combustion zone when no flame exists, combustion explosions can occur. The combination of a spark due to some type of "glowing" material and a "pocket" of fuel/air mixture at an explosive ratio can result in an explosion. Another scenario is relighting the boiler with an explosive mixture of fuel and air present. There have been numerous accidents in which the front or back of the boiler have blown off and through masonry walls with loss of life and property damage.

5.1.3 Checking a Flame Scanner
There are many potential tests for a flame scanner depending on the situation. The guiding principle is to try to check the scanner operating in the same mode that a potential failure might occur. The required test is then to cause the flame to extinguish by shutting off the fuel supply and to determine whether the flame scanner then causes the two automatic fuel shut-off valves to close. It is very important that the flame scanner be checked on both oil and gas firing.

A detailed step by step procedure is given for testing the flame scanner in Appendix A.

5.2 LOW FIRE PROVING SWITCH

5.2.1 Description
In the startup procedure for the boiler, the safest way to light the main burner is with a minimum of fuel input. Low fire proving switches are required by the VA to be position switches that are closed only if the fuel valves and air damper are in the low fire position. These low-fire proving switches have the function of not allowing the main flame to be ignited if the firing positions for fuel and air are not a minimum. A low fire proving switch can be located in the drive motor that causes the movement of the fuel valve or air damper but, in that case, all linkages between the drive motor and valve/damper must be drilled and pinned. In some electronic control systems, a potentiometer is used to determine the position of the inlet damper by the output of a voltage level to the controller. This potentiometer is not compliant with VA

requirements. Parallel position systems require separate proof of closure switches for the low fire position for air and both fuels while single point positioning systems require only a proof of closure switch on the fuel valve if linkages are properly drilled and pinned.

5.2.2 Consequences of a Failed Low Fire Proving Switch

Failure of the low-fire proving switch could allow the boiler to start in a high fire position. This result could easily lead to a violent combustion explosion with property loss as well as injury and death to individuals the area of the boiler.

5.2.3 Testing the Low-Fire Proving Switch

The low-fire proving switch should be tested during the boiler startup sequence. The switch is isolated and the switch set point is determined by a voltage measurement across the switch during boiler startup. A check to see if the boiler will attempt to light with the switch open is the final part of the test.

A detailed step by step procedure for testing the low fire proving switch is given in Appendix A.

5.3 COMBUSTION AIR PRESSURE SWITCH

5.3.1 Description

A combustion air pressure switch is used for the purpose of causing the two automatic fuel shutoff valves to close if the forced draft fan is not producing proper air pressure (See Figure 5.1). This switch uses a differential pressure measurement across the fan. The switch is in the safety control circuit anytime the boiler is in the run position. For a constant speed fan, the set point for the switch is established by measuring the minimum pressure differential seen by the switch over the firing range and setting its switch trip point at approximately 80% or more of the minimum differential pressure. For a variable speed forced draft fan, the set point is set by measuring the pressure differential across the fan during purge and setting the trip point at 35% or more of the pressure difference during purge. In order to meet the requirement for the variable speed forced draft fan, it will probably be necessary to limit the turn down on fan speed to 40 Hertz.

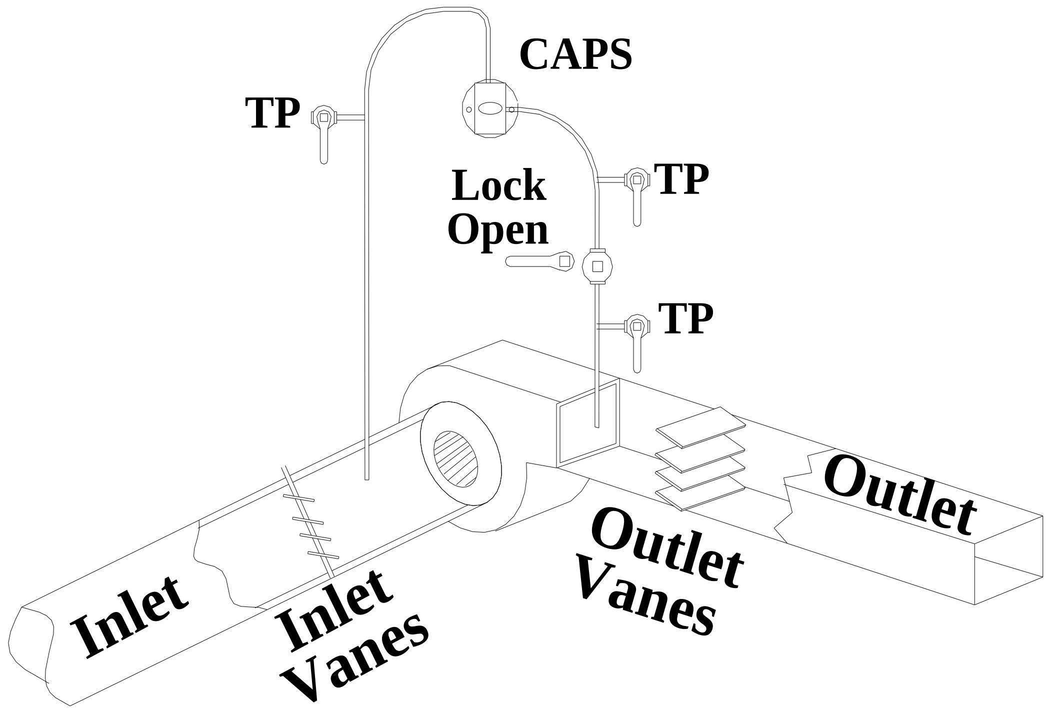


Figure 5.1 Combustion Air Pressure Switch

5.3.2 Consequences of a Failed Combustion Air Switch

If the fan fails to produce adequate combustion air, incomplete combustion will occur. Incomplete combustion can result in a combustion explosion and the production of carbon monoxide with its attendant toxicity can easily cause death for operators.

5.3.3 Testing Combustion Air Flow Switch

The first step in the test procedure is to establish the pressure difference on which to base the switch trip point. Separate procedures in Appendix A are given for the cases of constant and variable speed forced draft fans. Once this pressure difference has been established, the high pressure side of the switch can be isolated as shown in Figure 5.1. The pressure is then bled down and the set point determined.

A detailed step by step procedure for testing the combustion air flow switch is given in Appendix A.

5.4 PURGE AIR FLOW PROVING SWITCH

5.4.1 Description

The purpose of the purge airflow-proving switch (PAPS) is to ensure that during purging sufficient air volume is moved through the boiler. Four air changes are required for fire tube boilers and eight air changes are required for water tube boilers. Hence, the PAPS serves the role of proving airflow rate during purging. The PAPS works by measuring pressure change across a boiler. The switch should see a small pressure change at low fire with a much larger change in the purge (high fire) position. This pressure should be measured across the boiler without variable restrictions.

5.4.2 Consequences of a Failed Purge Airflow Proving Switch

If this switch were to malfunction, it would be possible to ignite the pilot or main flame with combustible gas mixtures present in the boiler. This could result in a combustion explosion.

5.4.3 Testing the Purge Airflow Proving Switch

The purge air flow proving switch should be tested during the boiler startup sequence. It is tested with the same procedure as the combustion air pressure switch.

A detailed step by step procedure for testing the purge air flow proving switch is given in Appendix A.

5.5 BURNER POSITION SWITCH

5.5.1 Description

Some manufacturers of oil burners require a position switch to indicate that the burner is in the correct position before firing. The switch is generally a simple proximity switch that is electrically closed by depression of the switch by the burner as it is fully inserted into the boiler. For those boilers utilizing this switch it must be tested.

5.5.2 Consequences of Burner Position Switch Failure

If the boiler could fire on oil with the burner partly retracted, fire, production of carbon monoxide, flame instability, and combustion explosions could result.

5.5.3 Testing the Burner Position Switch

The switch is tested by determining if the boiler would fire on oil with the burner partially retracted. If the switch is properly set up, the boiler control will not allow the boiler to leave purge with the burner out of position.

A detailed step by step testing procedure is given in Appendix A.

5.6 FORCED DRAFT MOTOR INTERLOCK

5.6.1 Description

The forced draft motor interlock provides an extra level of safety relative to proving "purge air flow" and "combustion air flow" and protects the fan motor from running with an inadequate power supply such as single phasing. There are three types of interlocks currently being used. The simplest interlock is an auxiliary contact which is a single pole switch that "makes" when the main switch supplying 3-phase power to the fan is closed. One could cut any or all of the power leads going to the motor and this switch would indicate acceptable operation. For this reason, this interlock is not acceptable. A second design utilizes phase monitors on all three legs that look at the incoming power characteristics that is able to detect a loss of incoming power to the panel. However, the fan motor could be disconnected electrically and the phase monitor would indicate acceptable operation. Again this interlock is not acceptable. The VA approved interlock is based on current relays in which current in all three legs supplying power to the motor is measured (See Figure 5.2). This interlock involves encircling each power lead with a current pickup. The lack of sufficient current through any of these current pickups will stop boiler operation. For testing, the VA requires the use of a type of current pickup around each lead that can be opened and removed without disconnecting the power lead from its terminal strip.

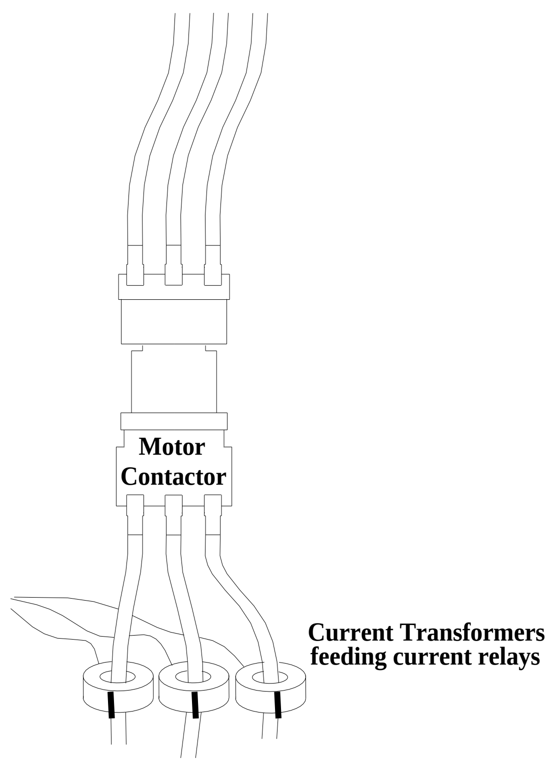


Figure 5.2 Forced Draft Motor Interlock

5.6.2 Consequences of a Failed Forced Draft Fan Motor Interlock

If the fan fails to run or runs at a lower speed, the boiler would produce combustibles leading to the same problems discussed in section 5.5.2.

5.6.3 Testing the Forced Draft Fan Motor Interlock

The test for this interlock consists of determining whether the right type of switch (current relays as shown in Figure 5.2) is in place and then removing the current pickups, one at a time, and determining if the boiler shuts down.

A detailed step by step procedure is given in Appendix A.

5.7 FURNACE PRESSURE INTERLOCK

5.7.1 Description

The purpose of the high furnace pressure interlock (FPI) is to ensure that the furnace pressure does not exceed an acceptable limit due to impeded flow. The FPI works by measuring pressure in the boiler furnace while the boiler is running. A pressure that exceeds the FPI set point "breaks" the interlock to an open position and causes the boiler to shut down.

5.7.2 Consequences of High Furnace Pressure Interlock Failure

A blockage in the exit portion of the boiler combustion gas circuit, leads to high furnace pressure and incomplete combustion. Under this condition carbon monoxide is generated and the combustion gases are potentially highly explosive. If the FPI were to malfunction two highly undesirable consequences might occur. First, high furnace pressure would cause incompletely combusted gasses internal to the boiler furnace to be expelled into the boiler room. Carbon monoxide levels in the boiler room could reach dangerous levels. Secondly, these incomplete combustion gases could explode if a supply of oxygen became available (For example the flame was temporary extinguished, and then explosively re-ignited by a "hot spot" in the boiler.) Therefore, the consequences of a failed FPI could be dangerous atmospheric conditions for the occupants of the plant and potential explosion.

5.7.3 Testing the Furnace Pressure Interlock

The FPI is tested by first determining the furnace pressure at high fire in order to establish a proper set point for the interlock. It can then be tested on line by isolating the switch and pressurizing the interlock with an air hand pump to determine its set point and action towards shutting off the boiler.

A detailed step by step procedure for testing the FPI is given in Appendix A.

5.8 OUTLET STACK DAMPER POSITION INTERLOCK

5.8.1 Description

The purpose of the outlet stack damper position interlock (OSDPI) is to ensure that the outlet damper is open during purge and, if the damper is non-modulating, that the damper remains open during boiler firing. Therefore, it is a pre-ignition interlock for a modulating damper. For a non-modulating damper, an open OSDPI must interrupt purge during the purge cycle or, if the boiler is firing, should shut down the boiler. The non-modulating damper can be welded into open position negating the need for an OSDPI. The OSDPI is a displacement electrical switch that should be activated by movement of the outlet damper into the correct position for purging. (In many cases this interlock is on the jackshaft drive motor that is linked to the damper; however this arrangement only meets VA specifications if all linkages are drilled and pinned.)

5.8.2 Consequences of Outlet Damper Position Interlock

A blockage in the exit portion of the boiler combustion gas circuit due to a closed or partially closed outlet damper, leads to inadequate flow of combustion air. Under this condition there is the potential for highly combustible gases to be present in the boiler furnace after purging is complete because the air flow restriction reduces the volume of purge gases to the point that combustible gases remain in the boiler or exhaust system. In the case of a non-modulating damper that is not welded open, the OSDPI helps prevent a situation of high levels of combustible gases in the furnace during boiler firing. If the OSDPI were to fail in this case, these incomplete combustion gases could explode.

5.8.3 Testing the Outlet Damper Position Interlock

The OSDPI is tested by measuring voltage to determine the point at which the interlock "makes". This point should be with the outlet damper more than 80% open. A wire can then be disconnected from the switch which would simulate a failed switch. The boiler should not prove purge under this condition. For a non-modulating damper the

OSDPI should cause the boiler to shut down during firing if the damper is not at least 80% open.

A detailed step by step procedure for testing the OSDPI is given in Appendix A.

5.9 FORCED DRAFT DAMPER WIDE OPEN PRE-PURGE PROVING SWITCH

5.9.1 Description

The FDDWOPS is required to show that the inlet vanes are wide open for purge for either a modulating or manually adjustable forced draft damper. A FDDWOPS is not required if the force draft damper is welded in the open position. This switch is of the proximity type. The VA required system is a switch actuated by the damper itself or the switch can be in the drive motor for a modulating damper if all linkages are drilled and pinned.

5.9.2 Consequences of a Failed FDDWOPS

If this switch failed, the boiler and stack could contain a highly explosive mixture of combustible gases due to inadequate purge. This gas mixture could explode when either the pilot or main flame are operated.

5.9.3 Testing the FDDWOPS

If required, the FDDWOPS should be tested during the boiler startup sequence. In addition, for a non-modulating damper that is not welded open, it must be tested as a running interlock with the boiler firing.

A detailed step by step procedure for testing the FDDWOPS is given in Appendix A.

5.10 PRE-PURGE AND POST-PURGE TIMERS

5.10.1 Description

There is a purge cycle at light off and also when the boiler shuts down. The purpose of purging is to make sure that no combustible gas is present in an unfired boiler upon shutdown or startup. It is necessary to prove that the purge cycle extends for the correct duration to achieve the required air changes, as determined by the applicable codes. A timer in the burner management system accomplishes this function. Older timers, no longer acceptable, can be adjusted in the field to any purge time duration. Timers that are acceptable are adjusted when the burner is commissioned and then the setting is "burned in" so that subsequent changes cannot be made without replacing the timer. Codes require that fire tube boilers have a minimum pre-purge of four air changes and water tube boilers a minimum of eight air changes. Before testing, one must verify the correct duration of the purge cycle. The US NFPA85 code requires a minimum of 15 second post purge time at the air flow present at time of shutdown.

5.10.2 Consequences of Improper Purge Timing

If the timer does not function correctly, the boiler and stack could contain a highly explosive mixture of combustible gases due to inadequate purge. This gas mixture could explode when either the pilot or main flame are operated.

5.10.3 Testing the Pre and Post Purge Timer

The test is simple in that the duration of purge can be measured simply with a stop watch. The amount of purge air moved is more difficult to determine. The test procedure given in Appendix A gives a formula for calculating the rate of purge air. This volume of purge air should exceed four times the fireside volume of a fire tube boiler and eight times the fireside volume of a water tube boiler.

A detailed step by step test procedure is given in Appendix A.

5.11 IGNITER TIMER AND MAIN FLAME IGNITION TIMER

5.11.1 Description

The igniter serves as a spark to light the pilot flame. Moving quickly from an ignition source to pilot light to main flame does not allow a large amount of combustible gas in the boiler without the presence of an ignition source at any time during light off. The igniter and main flame ignition time is controlled by the burner management system and must not be adjustable in the field. NFPA currently sets the maximum igniter spark duration of 10 seconds. For natural gas or light oil, the time allowed from the time that the two automatic shut off valves open until they close is 14 seconds (this is 10 sec for main flame ignition and 4 seconds for valves to close).

5.11.2 Consequences of Excessive Igniter or Main Flame Ignition Timing

If the igniter stays on too long and the pilot flame fails to ignite, an excessive amount of pilot gas could enter the boiler leading to a boiler explosion. Similarly, if the trial time for main flame ignition is excessive, large amounts of fuel could enter the boiler and subsequently explode

5.11.3 Testing the Igniter Timer or Main Flame Ignition Time

The test of igniter time requires that one close both the main and pilot fuel supplies and measure the time the igniter is on during startup of the boiler. To test the time for trial for main flame, pilot gas is supplied to the boiler with the main fuel line manual valve closed. With this set up, a stopwatch can be used to measure the time that the main fuel valves remain open during an attempt to start the boiler.

A detailed step by step procedure for these tests is given in Appendix A.

5.12 AUTOMATIC FUEL SHUTOFF VALVE CLOSURE TIME AFTER MAIN FLAME FAILURE

5.12.1 Description

When the main flame is extinguished for any reason, the flame scanner should sense a lack of flame and, through the burner management control system, cause the automatic fuel shutoff valves to close. It is essential that these valves close quickly to prevent large amounts of combustible fuel from entering the furnace without a flame present. It should take less than four seconds for the automatic fuel valves to close.

5.12.2 Consequences of Excessive Time to Close Main Fuel Valves

If large amounts of combustible fuel were present without a flame due to the automatic shut off valves remaining open too long after a flame failure, and subsequently ignition sources were applied, a massive boiler explosion would result.

5.12.3 Testing the Automatic Fuel Shutoff Valves Closure Time After a Main Flame Failure

The automatic fuel shutoff valve closure time can be tested at the same time the flame scanner is tested. The test is conducted with the boiler running. The fuel supply to the boiler is cut off by the manual valve located just before the burner and the time for the automatic fuel shut off valves to close is measured after the flame is observed to go out.

A detailed step by step test procedure is given in Appendix A.

5.13 AUTOMATIC FUEL SHUTOFF VALVE CLOSURE TIME AFTER PILOT FLAME FAILURE

5.13.1 Description

If the pilot flame fails during the ignition period, the flame scanner should sense a lack of flame and, through the burner management control system, close the automatic fuel shutoff valves.

5.13.2 Consequences of Excessive Automatic Fuel Shutoff Valve Closure Time

It is essential that these valves close quickly to prevent large amounts of combustible fuel from entering the furnace without a flame present. If large amounts of combustible fuel were present without a flame and subsequently ignition sources were applied, a massive boiler explosion would result.

5.13.3 Testing the Automatic Fuel Shutoff Valve Closure Time

See 5.12.3

5.14 MINIMUM PILOT FLAME TEST

5.14.1 Description

The startup sequence begins with an electronic spark that is used to ignite the gas pilot. The gas pilot in turn is used to start the main flame. The pilot flame is crucial to smooth ignition of the main flame. The length of the pilot flame is crucial to reliable ignition. The pilot flame needs to be of a length such that it will ignite the main flame very quickly to prevent the buildup of combustible fuel in the furnace. The pilot flame length increases with gas pressure supplied to it. The minimum possible gas pressure supplied to the pilot is guaranteed by the set point on the low gas pressure cutoff switch in the pilot fuel train. This set point should be equal to or more than 80% of the regulated pilot gas pressure. The shortest pilot flame that will reliably ignite the main flame occurs at this minimum pilot gas pressure. Hence, a test to determine if the pilot length is adequate should be done at this minimum pilot gas pressure.

A complication exists in many situations for the backup fuel source for the pilot. Many systems normally use natural gas for the pilot fuel with propane or propane-air mixtures as the backup fuel. Natural gas and propane-air mixes should exhibit about the same burning characteristics. Propane has more energy per unit volume than natural gas and hence will have a different flame shape. Testing should be done to prove that the pilot flame is acceptable with either natural gas or propane. This test will also verify that the pilot can be successfully operated on either fuel.

5.14.2 Consequences of Inadequate Pilot Flame

Accidents commonly occur when boiler operators make multiple unsuccessful tries to ignite the fuel. Typically, these accidents involve introducing significant amounts of fuel into the boiler in several attempts to fire the main burner. If purging is not adequate, an explosive mixture of fuel can be ignited. it must be remembered that that even in the case of one attempt for main flame ignition, failure to quickly ignite the flame because of inadequate pilot flame length can cause a devastating explosion.

5.14.3 Testing for Minimum Pilot Flame

The test involves setting the pilot gas pressure to a level of approximately 10% above the set point pressure on the low pilot gas cutoff switch. Then a trial is made to see if the pilot can smoothly light both gas and oil.

A detailed step by step procedure is given in Appendix A.

5.15 CONTROL AIR PRESSURE INTERLOCK

5.15.1 Description

Some older control systems use compressed air to operate various boiler controls. If air pressure is lost, the ability to regulate air and fuel flow into the boiler, feedwater flow, etc. is lost. A control air pressure interlock switch that continuously measures air pressure in the air supply lines to the boiler controls is required. If the air pressure drops below a level necessary to operate the controls, the switch will trip and not allow the boiler to start, or if the boiler is running, will shut the boiler down. The person testing this switch should know the required air pressure specified by the control manufacturer and should adjust the set point pressure on the interlock to 120% of the minimum allowed pressure. An alarm to indicate an approaching problem at a pressure higher than the interlock set point is desirable.

5.15.2 Consequences of Failed Control Air Pressure Interlock Switch

Low control air pressure could easily result in a situation in which the air/fuel ratio moves into a situation where a furnace explosion could occur or dangerous levels of carbon monoxide are generated. The explosion and toxic fumes that can be generated in this way could easily damage property and injure/kill people. Also if the feedwater control valve is pneumatically operated, low control air pressure could result in the boiler running out of water with the problems described in section 2.1.2.

5.15.3 Testing the Control Air Pressure Interlock

The test can be done with the boiler off. The control air pressure supplied to the switch can be reduced to define the set point. At this condition the boiler should not start.

A detailed step by step procedure is given in Appendix A.

5.16 FLUE GAS RE-CIRCULATION DAMPER SET FOR PRE-PURGE

5.16.1 Description

Some boilers are fitted with flue gas re-circulation in order to decrease NO_x levels produced in the combustion process. This system consists of a duct connected to the stack that re-circulates some flue gas into the incoming combustion air stream. Recirculation may also be accomplished internal to the boiler. There is a damper to control the amount of flue gas that is re-circulated. Boiler manufacturers have different requirements for the position of this damper on startup (Some manufacturers require it to be closed while others require it to be open. If the damper is to be open, the manufacturer should be contacted to determine if the manufacturer has a recommendation for additional purging.). The VA requires that a proximity switch be provided to insure the damper is in the manufacturers recommended position on light off. The switch can be at the damper or in the drive motor if all linkages are drilled and pinned.

5.16.2 Consequences of an Incorrectly Positioned Flue Gas Recirculation Damper During Purge

If the pre-purge cycle does not eliminate all combustible gases from the system before the ignition sequence, a massive explosion could occur.

5.16.3 Testing the Re-Circulation Damper Interlock Switch

The re-circulation damper interlock switch should be tested during the boiler startup sequence. The test procedure is similar to the test of the outlet damper position switch.

A detailed step by step procedure for testing the recirculation damper interlock switch is given in Appendix A.

5.17 LOW FLUE GAS OXYGEN LEVEL INTERLOCK

5.17.1 Description

The VA requires that all boilers have a low flue gas oxygen level alarm and interlock, which protects against firing with a "rich" fuel/air mixture. This system consists of using a zirconium oxide sensor in the stack to continuously measure oxygen. This signal is used to provide an alarm and interlock if the percent oxygen level falls below a set point. The set point should be as low as practical without the possibility of excessive CO and combustibles The VA requires that less than 200 ppm of CO and combustibles are present in the exhaust gas from the boiler. This interlock is electronically integrated into the burner management system for the boiler.

5.17.2 Consequences of a Failed Low Oxygen Alarm and Interlock

Insufficient combustion air results in flue gas with low oxygen and high combustibles which represent two very significant safety hazards. First, carbon monoxide will be a significant portion of the combustibles and can be fatal if breathed by humans at a sufficient level. Second, these combustible gases can produce a violent explosion if air is introduced in the presence of an ignition source.

5.17.3 Testing a Low Oxygen Alarm and Interlock

The low oxygen alarm is tested by supplying the interlock with test gas at a percent oxygen level above the minimum percent oxygen required to prevent excessive CO and combustibles with the boiler firing. This minimum percent oxygen level is determined during the required six month tuning of the boiler.

A detailed step by step procedure for the required test is given in Appendix A.

5.18 OUTSIDE AIR DAMPER POSITION ALARM

5.18.1 Description

Air for combustion must be available from the outside atmosphere (outside air) in the amount necessary to burn the fuel. Natural gas and oil require about 15 lb. of air to burn 1 lb. of fuel. The safety issue in this situation involves a scenario in which the outside air openings are closed to the point that insufficient air is supplied to the boiler. For any outside air supply equipped with a moveable damper, a proximity switch to provide an alarm in the case that the damper is not in its open position must be provided. In areas where the outside temperatures are relatively mild, a cheaper solution is to permanently install sufficient area to provide the necessary outside air for all boilers by either welding or locking windows open or replacing windows with fixed air intake louvers.

5.18.2 Consequences of Inadequate Outside Air

This situation will cause high levels of combustibles in the boiler. High combustibles represent two very significant safety hazards. First, carbon monoxide will be a significant portion of the combustibles and can be fatal if breathed by humans at a sufficient level. Second, these combustible gases can produce a violent explosion if air is introduced.

5.18.3 Testing the Outside Air Damper Alarm

Basically, the test involves determining whether sufficient outside air openings are guaranteed and sufficiently sized. If an outside air damper alarm is used to make that guarantee, it can be simply tested by slowly closing the outside air damper and noting the position at which the alarm sounded.

A detailed step by step procedure is given in Appendix A.

Appendix A. STEP BY STEP TEST PROCEDURES FOR STEAM BOILERS AND APPLICABLE HOT WATER BOILER SAFETY DEVICES

Appendix A.1. INTRODUCTION

Appendix A presents step by step test procedures for each safety device. The appendix provides forms for obtaining and recording all necessary data for each safety device being tested. It begins with tables that allow a thorough definition of the testing agency/personnel, responsible parties at the site, and boiler/burner data. This base data is followed by overarching requirements for safety testing. This information is then followed by one or two sheets for each device being tested to be used by the testing agency personnel as a check list and data form. These procedures must be made site specific to be in compliance with VA requirements. It is very important that all data required in these procedures are taken each time a test is made. Forms that contain pre-filled data lead to mistakes. Also it is important not to use a "check list form" because a reviewer cannot verify that the test has been done correctly due to absence of data.

Appendix A.2. ASSUMPTIONS FOR TEST PROCEDURE

The test procedures in Appendix A makes certain assumptions that are listed below. **PLEASE NOTE THAT THESE ITEMS ARE NOT ALWAYS REPEATED IN EACH TEST PROCEDURE BUT APPLY TO ALL TESTS.**

- After each test, equipment should be returned to normal operating condition and the boiler should be fired to confirm its operability.
- "Jumping" means disabling the switch electrically
- Any electric "jumper" application requires that all power to the device being "jumped" be shut off and only personnel that are trained and qualified to the correct level by NFPA 70E perform such tests.
- Pressure gages used in a test must be calibrated within prior 6 months.
- The set point is the value at which the safety device indicator is set. The trip point is the actual value at which the safety device activates. Some language used in the test procedures assumes that the set point equals the trip point.

Appendix A.3 BASIC INFORMATION

The final report should include the information required in Table A.3.1

Table A.3.1 Basic Information

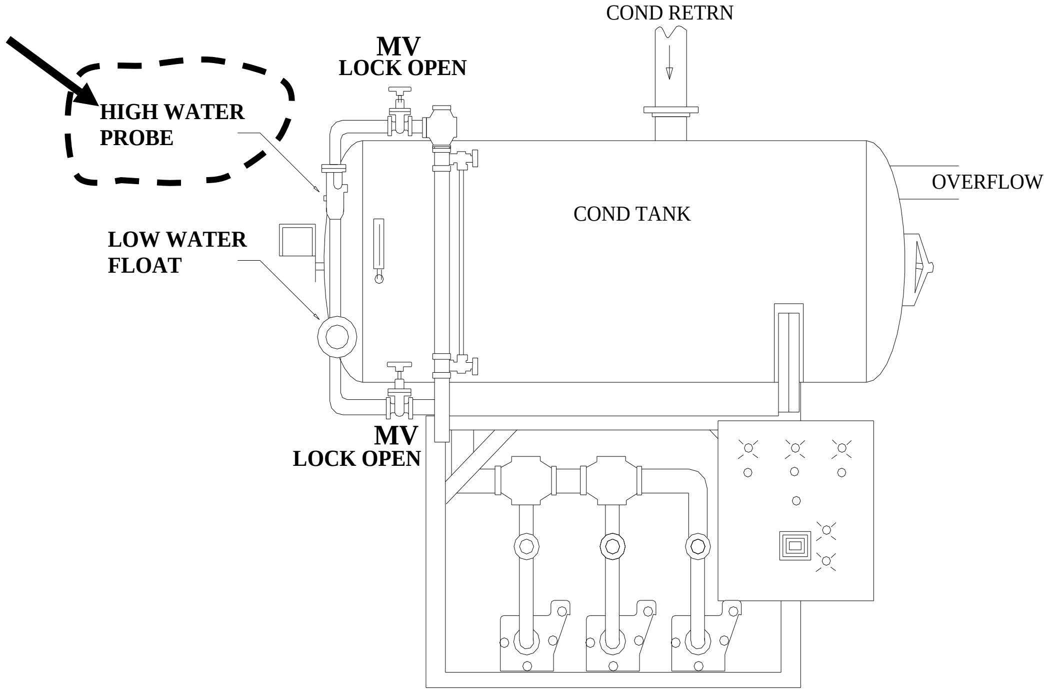
SITE INFORMATION	
VISN	
VA Medical Center Location	
Contact Information	
Phone	
Email	
Evaluators	
Date	
BOILER DESCRIPTION	
Boiler #	
Manufacturer	
Model and Capacity	
Serial #:National Board #	
Typical Operating Pressure	
Design Pressure	
Date of Manufacture	
BOILER CONTROL DESCRIPTION	
Manufacturer	
Model	
Date of Manufacture	
BURNER DESCRIPTION	
Manufacturer	
Model #	
Fuels	
Date of Manufacture	

Appendix A.4. REQUIRED CERTIFICATION
A VA compliant test report must contain the completed certification shown in section 1.3.2 on the first page following the cover page of the test report.

Checklist for High Water Alarm on Condensate Tank (HWACT)
(For Steam Boiler System only)

Item	Make/model	Device Type	Alarm Set point	Condensate Tank Diameter, Inches
HWACT				

*Alarm set point is required to be below 2/3rds of tank height & at least 4" below the overflow actuation point. Alarm type is required to be a probe.



- Drain sight glass without draining alarm column. Quickly close drain valve. Water level should quickly rise in sight glass indicating good communication with tank.
- If poor communication, clean lines and begin with the step above.
- Use bypass valve to add water to the condensate tank at a rate not to exceed 1 inch per minute. Use water level sight glass to observe point that alarm sounds. Tank can be either offline or online.
- Put maximum water supply to condensate tank and verify overflow is adequate.

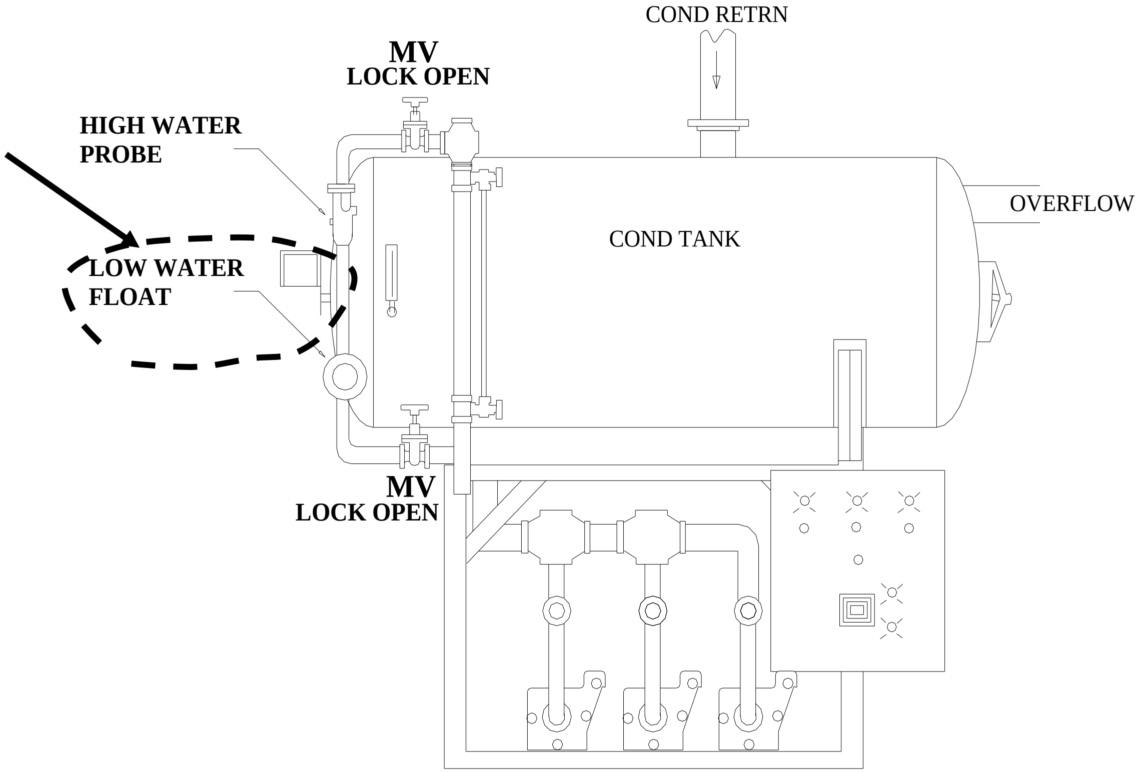
Result	Y/N	Water Level
Correct switch type and location?		
Did the alarm work correctly? Record water level		
Is overflow adequate?		

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required. Describe safety device failure/remedy in Appendix F.

Checklist for Low Water Alarm on Condensate Tank (LWACT)
(For Steam Boiler System only)

Item	Make/model	Device Type	Alarm Set point	Condensate Tank Diameter, inches
LWACT				

*Alarm set point is required to be above 1/3rd of tank height
*Device type is required to be a probe, float, or differential pressure sensor



- Drain sight glass without draining alarm column and then quickly close drain valve. Water level should quickly rise in sight glass indicating good communication with tank.
- If poor communication, clean lines and begin with the step above.
- Drain the water from the condensate tank at a rate not to exceeded 1 inch per minute. Use water level sight glass to observe alarm point. DO NOT ALLOW WATER LEVEL TO LEAVE SIGHT GLASS. Tank can be either offline or online.

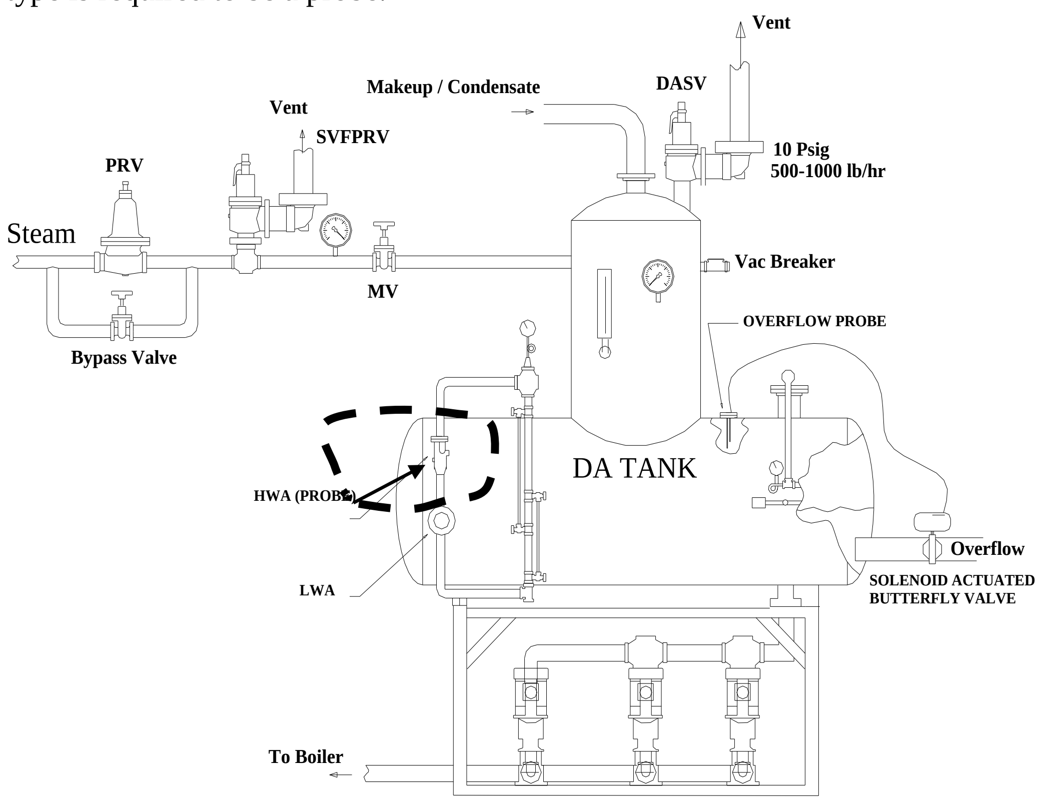
Result	Y/N	Water Level
Correct switch type and location?		
Did the alarm work correctly? Record water level		

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required.
Describe safety device failure/remedy in Appendix F.

Checklist for High Water Alarm on Deaerator Tank (HWADT)
(For Steam Boiler System only)

Item	Make / Model	Device Type	Alarm Set point	DA Tank Diameter inches
HWADT				

*Alarm set point is required to be below 2/3rds of tank height & at least 4” below the level at which the overflow valve actuates.
*Alarm type is required to be a probe.



- Drain sight glass without draining alarm column and then quickly close drain valve. Water level should quickly rise in sight glass indicating good communication with tank.
- If poor communication, clean lines and begin with the step above.
- Use bypass valve to add water to the deaerator at a rate not to exceed 1 inch per minute. Use water level sight glass to observe point that alarm sounds. DO NOT ALLOW WATER LEVEL TO LEAVE SIGHT GLASS

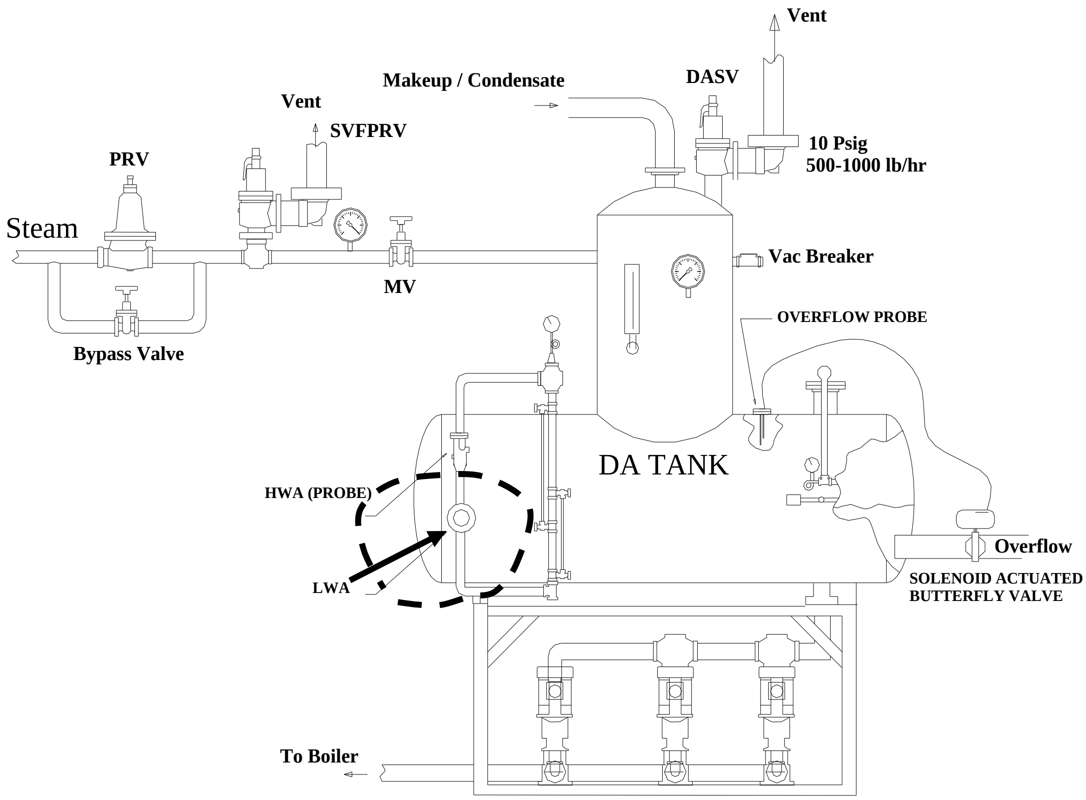
Result	Y/N	Water Level
Correct switch type and location?		
Did the alarm work correctly? Record Water Level.		

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required. Describe safety device failure/remedy in Appendix F.

Checklist for Low Water Alarm on Deaerator Tank (LWADT)
(For Steam Boiler System only)

Item	Make / Model	Device Type	Alarm Set point	DA Tank Diameter inches
LWADT				

*Alarm set point is required to be above 1/3rd of tank height.
*Device type is required to be a probe, float, or differential pressure sensor



- Drain sight glass without draining alarm column and then quickly close drain valve. Water level should quickly rise in sight glass indicating good communication with tank.
- If poor communication, clean lines and begin with the step above.
- Use bypass valve to add water to the deaerator at a rate not to exceed 1 inch per minute. Use water level sight glass to observe point that alarm sounds. DO NOT ALLOW WATER LEVEL TO LEAVE SIGHT GLASS

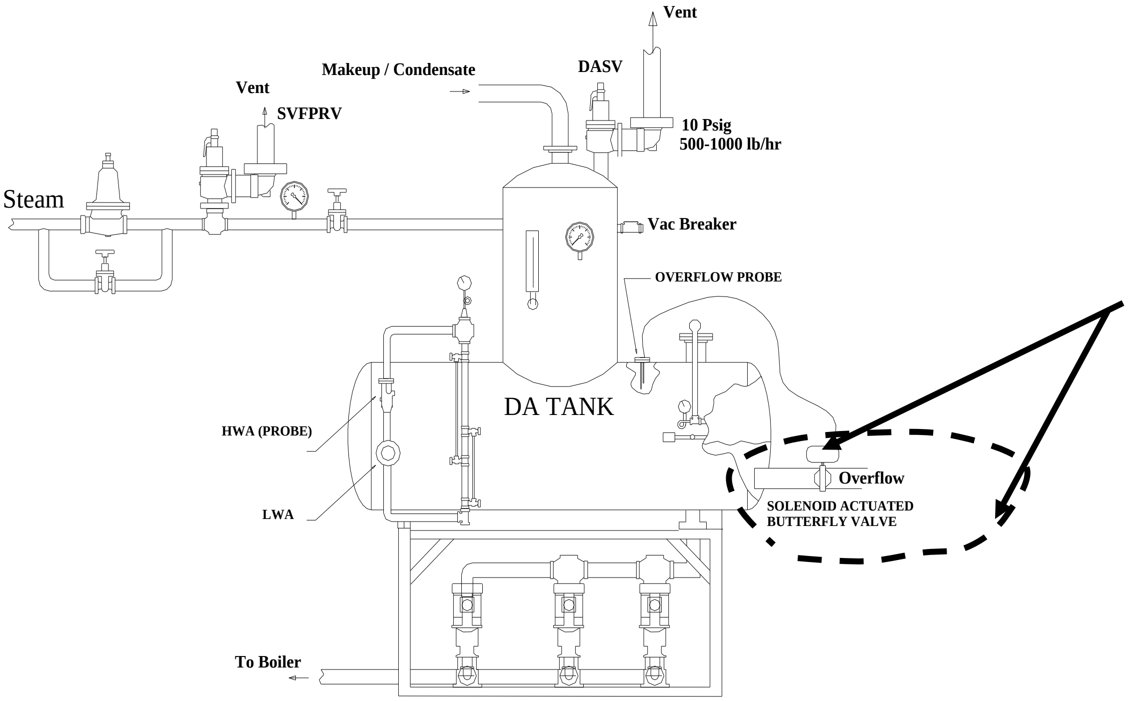
Result	Y/N	Water Level
Correct switch type and location?		
Did alarm work correctly? Record water level.		

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required.
Describe safety device failure/remedy in Appendix F.

Checklist for Deaerator Overflow Drain System (DAODS)
(For Steam Boiler System only)

Item	Make / Model	Device Type	Overflow Setpoint	Tank Diameter inches
DAODS				

*Overflow system is required to be a conductivity probe or differential pressure sensor connected to electronic valve that is not used in level control.
*Setpoint is required to be at least 4” below top of tank. If overflow drains to condensate tank, the condensate tank is required to be properly treated as a pressure vessel.



- Drain the sight glass and quickly close drain valve. Water level should quickly rise in sight glass indicating good communication with tank.
- Open manual bypass valve to supply feedwater at maximum rate.
- Determine that overflow valve has opened by using sight glass in drain line or visually observing drain. Use water level in sight glass on tank to observe whether overflow valve maintains water level visible in sight glass. DO NOT ALLOW WATER LEVEL TO LEAVE SIGHT GLASS.

Result	Y/N	Water Level
Correct device and location?		
Did the overflow valve work correctly? Record Water level.		
View port in place to view overflow?		

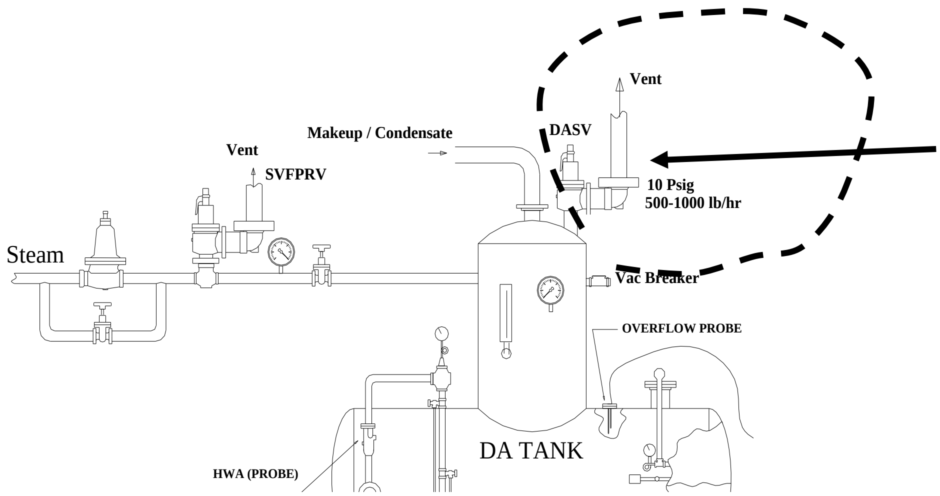
Did the device fail or pass the 3 Question Criteria (section 1.3.1)?   Pass   Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required.
Describe safety device failure/remedy in Appendix F.

Checklist for Deaerator Safety Valve (DASV)
(For Steam Boiler System only)

Item	Make	Capacity (lb/hr)	Range	DASV Set point	DA PRES (psig)
DASV					
Pressure Gage					

*Setpoint is required to be about 5 PSIG higher than DA pressure with capacity
*Capacity is required to be approximately (1000 lb/hr)
*DASV is required to be directly vented outside.
*Vent line is required not to contact drip pan ells when hot.

Item	Make	Type	MAWP	NDT (date)
Deaerator				



- Is NDT current within six years. If not obtain inspection before proceeding.
- Test the drains on the safety valve drip pan ells by pouring water into them and noting that water flows freely. Unstop drains before proceeding.
- Slowly open bypass valve to raise pressure until safety lifts. DO NOT RAISE PRESSURE MORE THAN 2 PSIG ABOVE SET POINT PRESSURE.
- Re-seat pressure should be about 6% less than lift pressure.
- After lifting valve, close bypass valve and allow safety to reseat.

Result	Y/N	Pressure
Correct installation?		
Did the safety valve work correctly?		
What was the safety valve relief pressure?		
What is the re-seat pressure?		
Is vacuum breaker present (VA requirement)?		
Is NDT current within the 6 year window?		

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required.
Describe safety device failure/remedy in Appendix F.

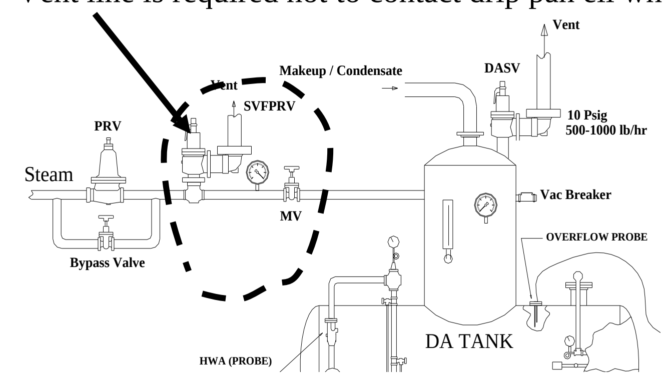
Checklist for Steam Safety Valve Following PRV (SVFPRV)-Deaerator (For Steam Boiler System only)

Item	Make	Capacity (lb/hr)	Range	SVFPRV Set point	DA PRES (psig)
SVFPRV					
Pressure Gage					

*Setpoint should be about 5 PSIG higher than DA safety lift point.

Item	Make/ Type	Size (in)	Pressure upstream	Pressure downstream	*Wide Open Flow Capacity lb/hr
PRV					
Bypass					

*SVFPRV is required to relieve largest of wide open flow capacity, PRV or bypass valve.
*Manual valve downstream SVFPRV is required
*SVFPRV is required to be directly vented outside.
*Vent line is required not to contact drip pan ell when hot.



- Test the drains on the safety valve drip pan ells by pouring water into them and noting that water flows freely. Unstop drains before proceeding.
- Close the manual valve in steam line following the safety valve.
- Slowly open bypass valve to raise pressure until safety lifts. DO NOT RAISE PRESSURE MORE THAN 2 PSIG ABOVE SETPOINT PRESSURE.
- Re-seat pressure should be about 6% less than lift pressure.
- Use manufacturer data to determine wide open capacity of PRV and bypass valve.
- Open larger of the bypass valve or PRV completely and perform accumulation test. The pressure should rise no more than 6% above the setpoint pressure. After lifting valve, close bypass valve, open manual valve in steam line after PRV and allow safety to reseat

Result	Y/N	Pressure
Correct installation?		
Did the safety valve work correctly? Record relief Pressure.		
What was the re-seat pressure?		

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required. Describe safety device failure/remedy in Appendix F.

Checklist for Steam Safety Valve Following PRV (SVFPRV) –Other*
(For Steam Boiler System only)

*NOTE: Perform this test of all steam safety valves following a PRV in boiler room.

Item	Make	Capacity (lb/hr)	Range	SVFPRV Set point	Upstream (psig)
SVFPRV					
Pressure Gage					

*Setpoint should be about 5 PSIG higher than DA safety lift point.

Item	Make/ Type	Size (in)	Pressure upstream	Pressure downstream	*Wide Open Flow Capacity lb/hr
PRV					
Bypass					

*SVFPRV is required to relieve largest wide open flow capacity, PRV or bypass valve.
*Manual valve downstream SVFPRV is required
*SVFPRV is required to be directly vented outside.
*Vent line is required not to contact drip pan ell when hot.

- Test the drains on the safety valve drip pan ells by pouring water into them and noting that water flows freely.   Unstop drains before proceeding.
- Close the manual valve in steam line following the safety valve.
- Slowly open bypass valve to raise pressure until safety lifts. DO NOT RAISE PRESSURE MORE THAN 2 PSIG ABOVE SETPOINT PRESSURE.
- Re-seat pressure should be about 6% less than lift pressure.
- Use manufacturer data to determine wide open capacity of PRV and bypass valve.
- Open larger of the bypass valve or PRV completely and perform accumulation test. The pressure should rise no more than 6% above the set point pressure.
- After lifting valve, close bypass valve, open manual valve in steam line after PRV and allow safety to reseat.

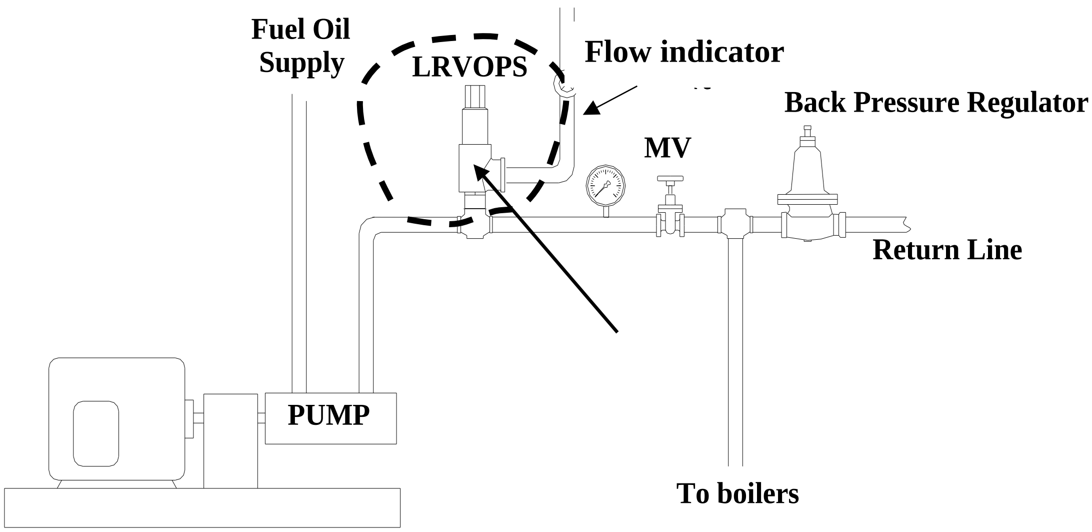
Result	Y/N	Pressure
Correct installation?		
Did the safety valve work correctly? Record relief Pressure.		
What was the re-seat pressure?		

Did the device fail or pass the 3 Question Criteria (section 1.3.1)?   Pass   Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required.
Describe safety device failure/remedy in Appendix F.

Checklist for Liquid Relief Valve on Oil Pump Set (LRVOPS)

Item	Make	Capacity (gal/hr)	Range	LRVOPS Set point	Oil Supply Pressure
LRVOPS					
Pressure Gage					

*Setpoint is required to be less than the max allowable pump pressure and less than 10 psig above normal regulated oil supply pressure.
* LRVOPS is required not to be used as a backpressure regulator.



- Slowly close manual valve in oil line after relief valve or raise pressure regulator set pressure until relief valve lifts (use view port to determine if valve is open).
- The pressure should rise no more than 10 psig above normal regulated oil supply pressure.

Result	Y/N	Pressure
Correct installation?		
Did the relief valve work correctly? Record Lift Pressure		
Did valve re-seat? List reseat pressure.		
View port in place to view oil flow thru relief valve?		
Is a back pressure regulator present?		

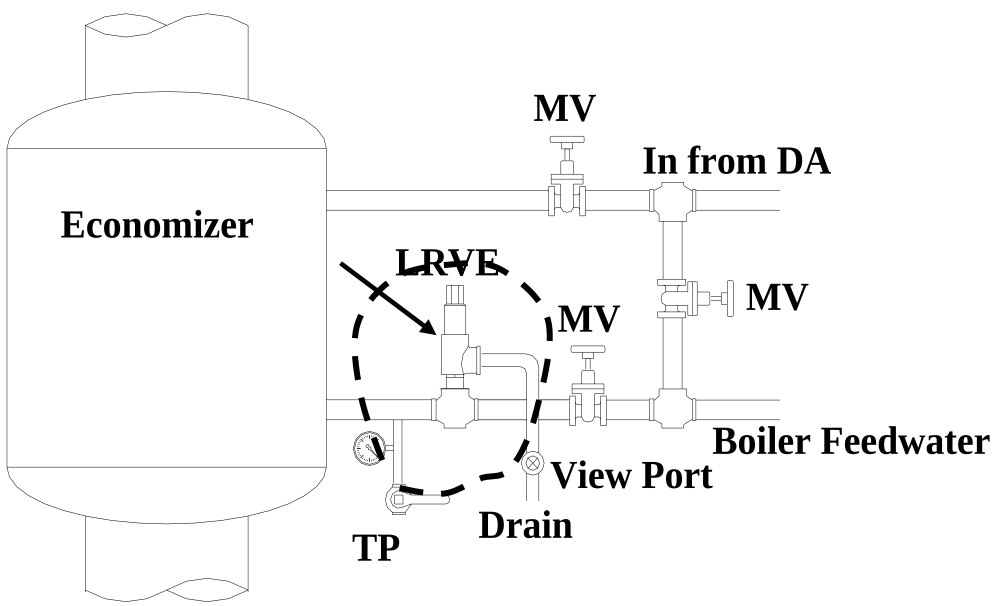
Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required. Describe safety device failure/remedy in Appendix F.

Checklist for Liquid Relief Valve on Economizer (LRVE)

Item	Make	Capacity (gal/hr)	Range	LRVE Set point	Feedwater Pressure
LRVE					
Pressure Gage					

*Setpoint is required to be less than the 90% of max allowable economizer pressure and at least 10% above the maximum feedwater pressure. The relief valve must lift in the range of $\pm 3\%\ of$ of the setpoint pressure of the relief valve.

Item	Make	Max Stack Temp	MAWP
Economizer			



- With boiler offline use manual valves shown in above figure to isolate economizer and relief valve. Use hydrostatic test pump to raise pressure and open relief valve (use view port to determine when valve is open). DO NOT RAISE PRESSURE MORE THAN ALLOWABLE ECONOMIZER PRESSURE!

Result	Y/N	Pressure, psig
Correct installation?		
What is the stamped relief valve lift pressure on the LRVE?		
What was the relief valve lift pressure?		
Maximum allowable economizer pressure?		
Maximum feedwater pump pressure?		
Did the LRVE work correctly within required pressure limits?		
View port in place to view water flow thru relief valve?		

Did the device fail or pass the 3 Question Criteria (section 1.3.1)?   Pass   Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required. Describe safety device failure/remedy in Appendix F.

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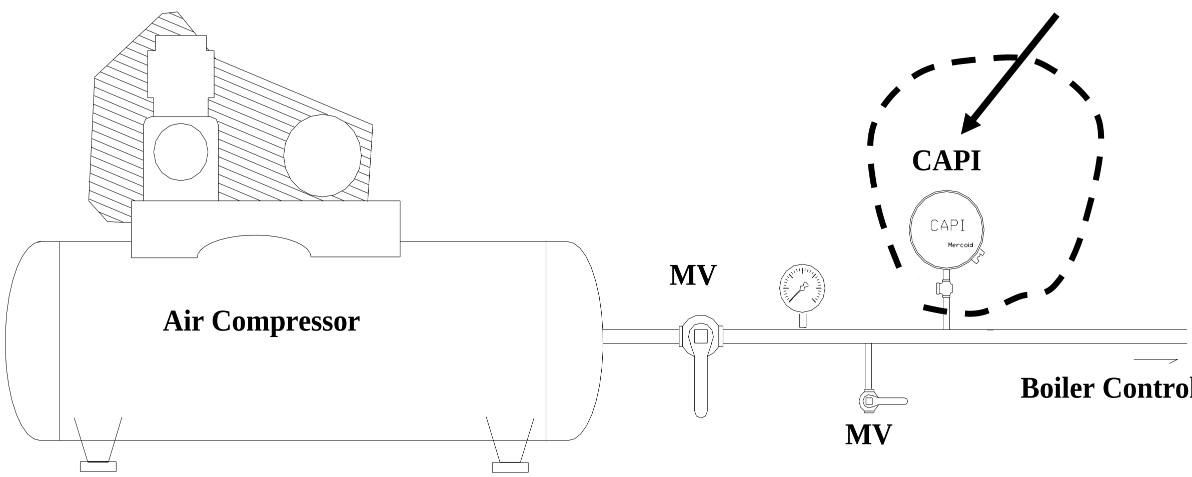
Checklist for Control Air Pressure Interlock (CAPI)

Item	Make	Range (psig)	Switch Set point	Regulated Pressure	Minimum Required Pressure
CAPI					
Pressure Gage					

*Setpoint is required to be more than minimum pressure required to actuate any pneumatic control device.
*CAPI is required to be after any pressure regulator in line serving pneumatic devices.



- Slowly close manual test valve to lower air supply pressure. Observe the pressure at which boiler shuts down. DO NOT LOWER PRESSURE BELOW REQUIRED PRESSURE TO ACTUATE ANY PNEUMATIC CONTROL DEVICE!

Result	Y/N	Trip Point Pressure
Correct location?		
Did the CAPI work correctly?		
Is a lockable manual test valve in place as shown in figure?		
What was the interlock trip point pressure?		
Is the setpoint higher than pressure required to actuate any pneumatic control device		

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required.
Describe safety device failure/remedy in Appendix F.

Checklist for Propane Pilot Backup System

Note: This test ensures that backup fuel can be fired in the case of loss of natural gas to plant. This test is to determine the reliability of the backup pilot system in its ability to light the boiler when firing on fuel oil. The same safety devices as those used for a natural gas pilot are used to ensure the safety of this operation.

- Connect and/or align propane system to boiler.
- Attempt to light boiler FIRING ON FUEL OIL.

Result	Y/N
Is Propane Pilot Backup System in place and operable?	

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required. Describe safety device failure/remedy in Appendix F.

Checklist for Carbon Monoxide and Combustible Gas Alarms in the Boiler Plant

Item	Make	Number of Alarms	Alarm Set point
Combustible Alarm			
CO Alarm			

*CO setpoint is required to be 50 ppm or less.
*Combustible set points are required to be 10% or less of the LEL.
*Test gasses for CO is required to be 50 ppm or less and for combustibles is required to be 10% or less LEL
*Location and number of CO and combustible sensors defined by VA Design Manual
.

- Use test gases in accordance with manufacturer's recommendation to test alarms.

Result	Y/N	Alarm Point
Correct test gas?		
Did the combustibles alarm work correctly?		
Did the CO alarm work correctly?		
Are the number and locations of the sensors adequate?		

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required.
Describe safety device failure/remedy in Appendix F.

Checklist for Outside Air Damper Alarm (OADA)

- The required outside air opening area (ft^2) = 10 x boiler HP/250
  Note:
  1. Boiler HP is total capacity served by opening
     The equation is valid up to 1000 ft of elevation. Add 3% to opening area for each additional 1000 ft of elevation.
- Any moveable damper used to supply outside air to a boiler requires an OADA.

Measure the opening area used to supply air to boilers (either fixed or damper operated)

Result	**Boiler HP Served**	**Required outside air Opening area, ft^2 (see above formula)**	**Fixed Opening Area, ft^2**	**Damper Operated Opening Area, ft^2**

- If OADA exists, close outside air damper and prove that alarm activates with damper more than 80% open

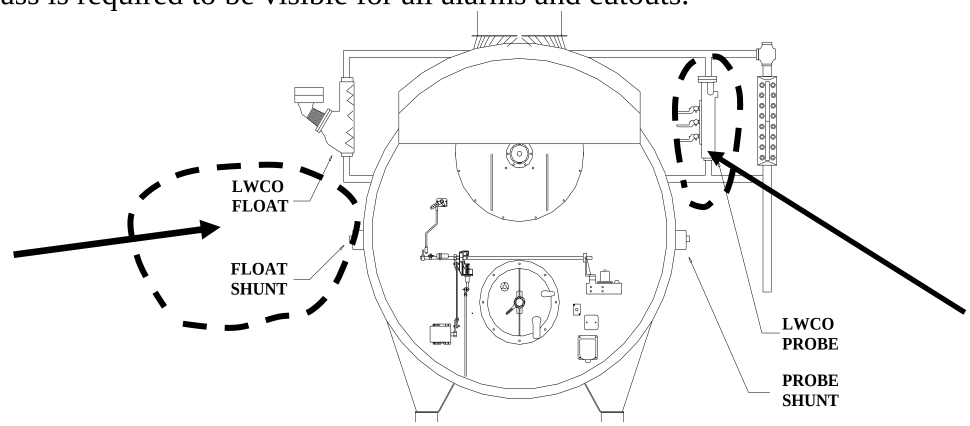
Result	**Y/N**
Is there adequate opening to supply combustion air for all boilers?	
Is there an OADA on all moveable dampers used to supply outside air to boilers?	
If OADA exists, did it work correctly?	

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required. Describe safety device failure/remedy in Appendix F.

Checklist for Low Water Alarm and Cutoffs on Boiler (LWA/LWCO/ALWCO) (For Steam Boiler System only)

Item	Make	Float / Probe
LWA		
LWCO		
ALWCO		

*An Independent shunt (bypass) switch is required to be installed for each LWCO
*The VA requires one float and one probe low water cutoff. No automatic re-start after a low water cut out is allowed by the VA.
*Visible separation of water level in sight glass between all alarms is required. Water level in sight glass is required to be visible for all alarms and cutouts.



- IN PERFORMING TEST NEVER LET WATER LEVEL LEAVE SIGHT GLASS!!!
- Drain sight glass without draining alarm column. Quickly close drain valve. Water level should quickly rise in sight glass indicating good communication with boiler.
- If poor communication, clean lines and begin with the step above.
- With boiler in manual at low fire, close the feedwater valve to generate a slow drain. You may "crack" the blowdown valve but do not exceed a drain rate of 1 inch per minute. Use water level in sight glass to observe alarm point. The alarm should sound first.
- Continue to drain until the primary cutoff activates.
- If shunt (bypass switch) exists, verify that it **ONLY** isolates the LWCO.
- Shunt (use bypass switch) the primary cutoff, restart the boiler, and set up drain as described above until the secondary cutoff activates..

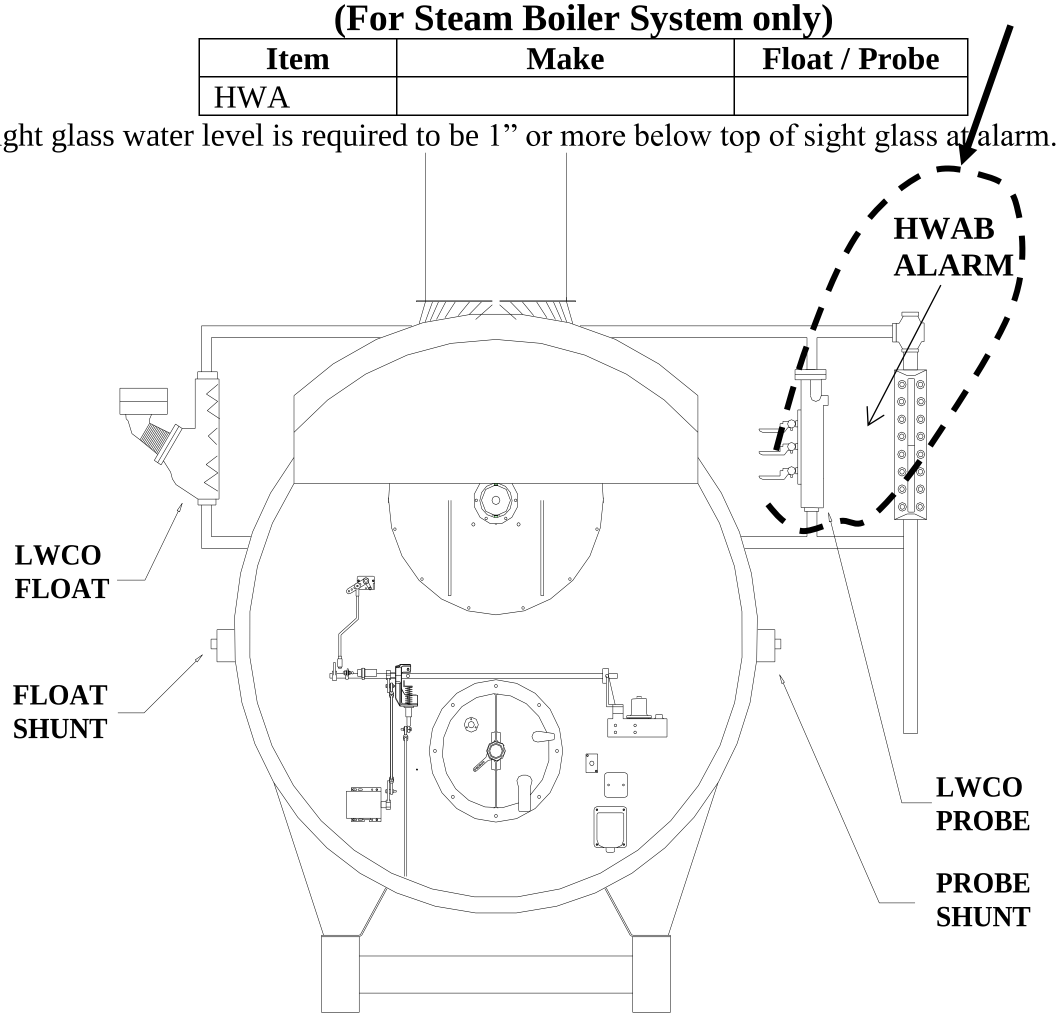
Result	Y/N	Water Level
Correct installation including shunts?		
Did the LWA work correctly? Record Level.		
Did the Primary cutoff work correctly? Record Level.		
Did the secondary cutoff work correctly? Record Level		
Was the alarm point above the primary and secondary cutoff point?		

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required.
Describe safety device failure/remedy in Appendix F.

Checklist for High Water Alarm on Boiler (HWAB)
(For Steam Boiler System only)

Item	Make	Float / Probe
HWA		

*Sight glass water level is required to be 1" or more below top of sight glass at alarm.



- Drain sight glass without draining alarm column and quickly close drain valve. Water level should quickly rise in sight glass indicating good communication with boiler.
- If poor communication, clean lines and begin with the step above.
- With boiler off, open the bypass feedwater valve to fill the boiler. Use water level in sight glass to observe alarm point. The alarm should sound before water level leaves sight glass. DO NOT ALLOW WATER LEVEL TO LEAVE SIGHT GLASS
- Close the bypass on feedwater line

Result	Y/N	Water Level
Correct Installation?		
Did the high water alarm work correctly? Record Level.		

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required.
Describe safety device failure/remedy in Appendix F.

Checklist for Recycle and Non-Recycle Boiler Steam Pressure Limit Switches (RBSPLS & NRBSPLS) (For Steam Boiler System only)

Item	Make	Range (psig)	Switch Setpoint	Normal Steam Pressure (psig)	Lowest SVB Setpoint (psig)
RBSPLS					
NRBSPLS					
Pressure Gage					

*RBSPLS setpoint is required to be 10 psig or more above normal steam pressure.
*NRBSPLS setpoint is required to be 5 psig or more above the RBSPLS pressure setpoint & 5 psig or more less than the lowest SVB setpoint.

RBSPLS TEST

- Never exceed the boiler MAWP during this test.
- Place boiler in minimum fire and manually close the steam supply valves from the boiler.
- Raise the steam pressure slowly by firing the boiler.
- Raise until RBSPLS activates – record activation pressure in table below.

NRBSPLS TEST

- Jumper the recycle switch out of the circuit.
- Fire boiler and raise the steam pressure slowly.
- Raise until NRSBPLS activates – record activation pressure in table below.

Result	Y/N	Trip Pressure
Is the RBSPLS setpoint 10 psig or more above normal steam pressure.? Record Pressure.		
Is the NRSBPLS setpoint 5 psig or more above the RBSPLS pressure setpoint & 5 psig or more less than the lowest SVB setpoint? Record Pressure.		
Did both switches work correctly?		

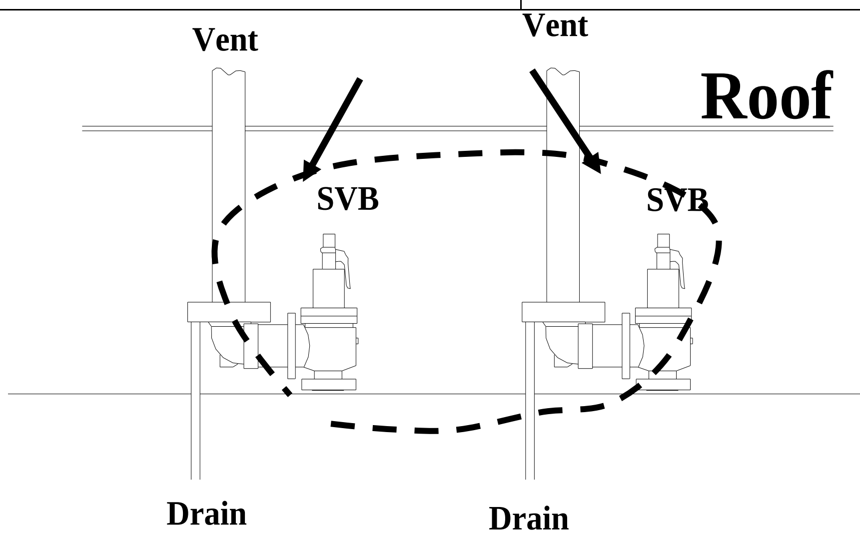
Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required. Describe safety device failure/remedy in Appendix F.

Checklist for Steam Safety Valves on Boiler (SVB)
(For Steam Boiler System only)

Item	Make	Capacity (lb/hr)	Range	SVB Setpoint	Normal Steam Pressure
SVB 1					
SVB 2					
SVB 3					
Pressure Gage					

*SVB1 is required to be set 5 psig higher than NRBSPLS & 10 psig below boiler MAWP.
*SVB2 is required to be set 5 psig or higher than SVB1 & 5 psig or more below boiler MAWP.
*Each SVB is required to be directly vented to outside.
*Vent lines are required not to contact drip pan ells when hot.

Item	MAWP (psig)	Capacity (lb/hr)
Boiler		



- NEVER ALLOW BOILER PRESSURE TO EXCEED MAWP
- With boiler off, jumper recycle and non-recycle steam pressure switches.
- Close the steam supply valves from the boiler and test the drains on the safety valve drip pan ells by pouring water into them and noting that water flows freely.   Unstop drains before proceeding.
- Raise the steam pressure slowly by firing the boiler at low fire.
- Note the pressure that the first & subsequent safety valves opened. (may require increasing firing rate).
- Place boiler in high fire and determine if steam pressure rises with both SVB open (Accumulation Test).
- Shut boiler off and note the pressures that the safety valves close.

Checklist for Steam Safety Valves on Boiler (SVB) (Continued)

Result	Y/N	Lift (P)	Reseat (P)
Is the Lift & Reseat Pressure correct for #1 SVB? Record Pressures. (See info below for correct values)			
Is the Lift & Reseat Pressure correct for #2 SVB? Record Pressures. (See info below for correct values)			
Is the Lift & Reseat Pressure correct #3 SVB? Record Pressures. (See info below for correct values			
Did accumulation test meet requirement listed below? Maximum pressure during accumulation test?			
Is SVB vent plumbing adequate?			

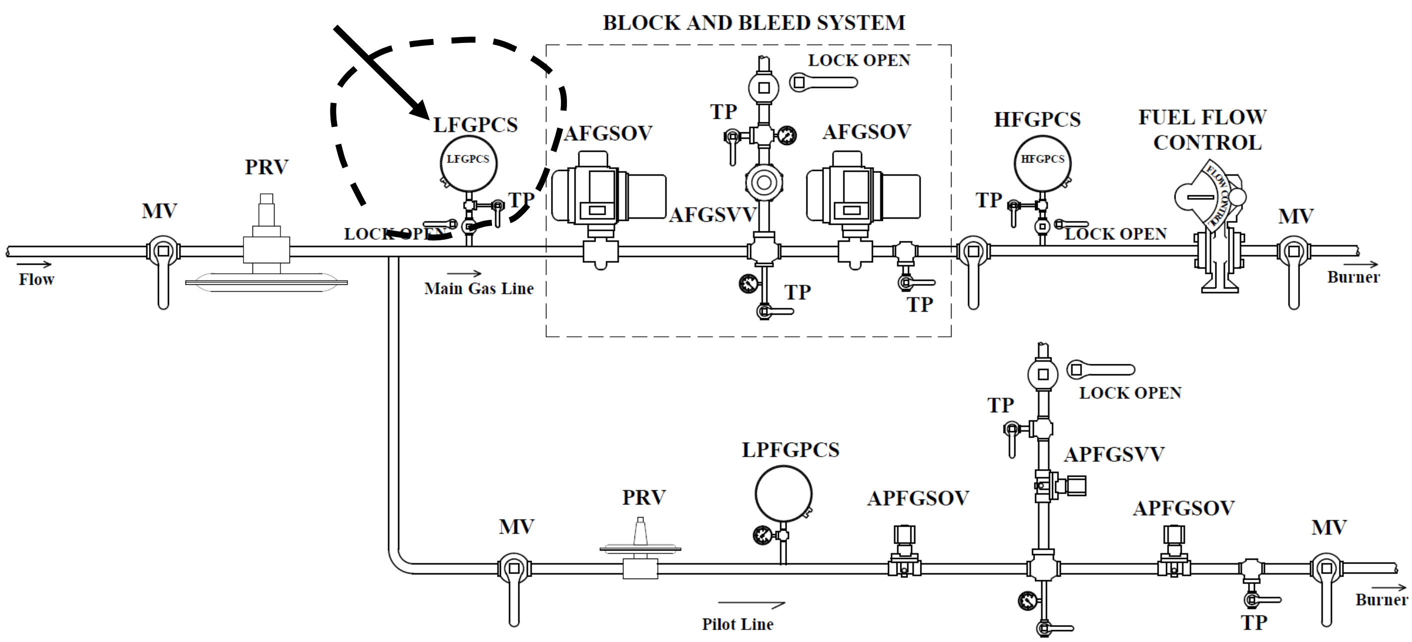
*Max lift pressure of 3% higher than rated lift pressure. Difference between the lift and reseat pressure should be more than the greater of 2 psig or 2% of the set pressure, and shall not exceed 6% of set pressure.
*Maximum accumulation pressure seen with all SVB's open and boiler in high fire should not exceed 110% of highest SVB setpoint and never exceed boiler rated pressure.

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required. Describe safety device failure/remedy in Appendix F.

Checklist for Low Fuel Gas Pressure Cutoff Switch (LFGPCS)

Item	Make	Range (inwc/psig)	Switch Setpoint (inwc/ psig)	Regulated Pressure (inwc/psig)
LFGPCS				
Pressure Gage				

*LFGPCS is required to be downstream of PRV and upstream of AFGSOV with a setpoint of 80% or higher than regulated pressure. The use of snubbers or dampeners on LFGPCS is prohibited.



- Connect a line containing a test pressure gage followed by a manual needle or globe bleed valve to the test port. The manual valve should be closed.
- Open test port valve.
- With boiler in low fire close lockable manual valve isolating the LFGPCS.
- Slowly open manual bleed valve to reduce pressure until boiler trips offline.

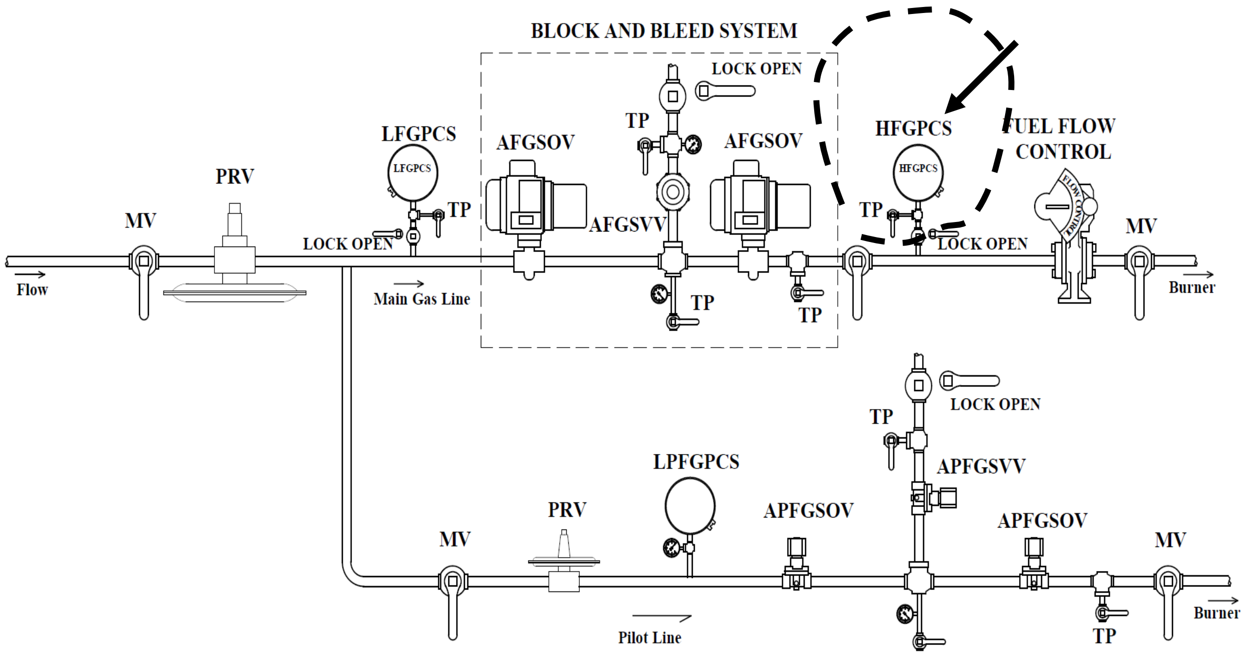
Result	Y/N	Pressure
Correct location?		
Did the switch work correctly? Record trip pressure.		
Is switch trip point 80% or more of regulated pressure?		
Are snubbers or dampeners **not** used?		

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required. Describe safety device failure/remedy in Appendix F.

Checklist for High Fuel Gas Pressure Cutoff Switch (HFGPCS)

Item	Make	Range (inwc/psig)	Switch Setpoint (inwc/ psig)	Regulated Pressure (inwc/psig)
HFGPCS				
Pressure Gage				

*HFGPCS is required to be downstream of PRV & upstream of flow control with setpoint less than 120% of regulated pressure.



- Connect a line containing a test pressure gage followed by a manual needle or globe bleed valve to the test port.
- Open test port valve and manual valve in the line connected to test port.
- With boiler in low fire close lockable manual valve isolating the HFGPCS.
- Use a hand air pump to slowly raise the pressure on the HFGPCS but NO HIGHER THAN 120% OF REGULATED PRESSURE.

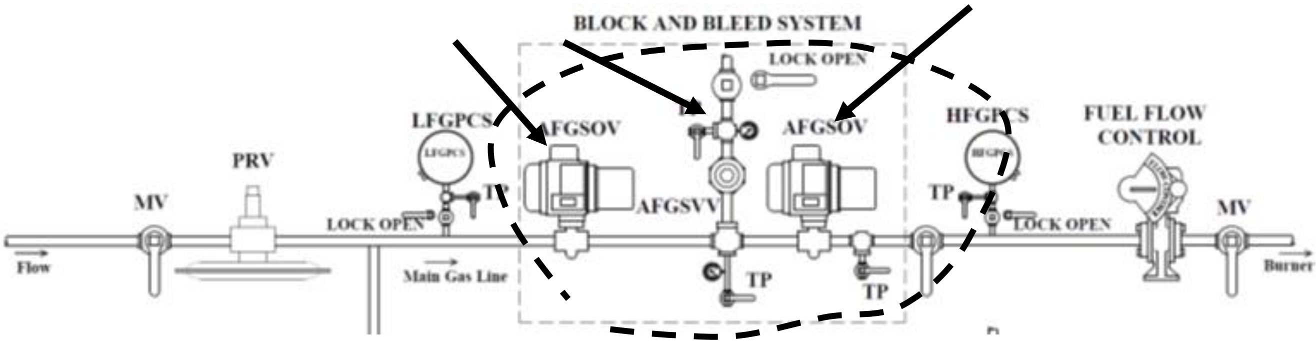
Result	Y/N	Switch Trip Point
Correct location?		
Did switch work correctly? Record Pressure		
Is switch trip point 120% or less of regulated pressure?		

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required. Describe safety device failure/remedy in Appendix F.

Checklist for Automatic Fuel Gas Shutoff Valves and Solenoid Vent Valve Seat Leakage (AFGSOV & AFGSVV) – Main Gas Line

Item	Make	Range (inwc/psig)
AFGSOV		
AFGSVV		
Pressure Gage		

*Maximum allowable leak rate is zero bubbles in 2 minutes.



Vent Valve Leak Test

- Connect flexible tubing (approximately ¼ inch diameter and approximately 3 feet long) to the test port in the vent line. Place the open end of the flexible tubing approximately ¼ inch deep in a cup of water.
- With the boiler running in low fire, close the manual lockable valve in the vent line and open the test port valve. If no bubbles appear in the water within a two-minute time period, the vent valve passes.

Upstream AFGSOV Leak Test

- Connect a pressure gage to the test port downstream of the two AFGSOV's and open the test port valve. With the boiler running in low fire, close the manual lockable valve in the vent line and then quickly close the manual valve in the main gas line downstream of the two AFGSOV's. Observe the pressure gage to make sure the manual valve does not leak. Bleed the pressure by briefly opening and then re-closing both the manual vent valve and the manual main gas line valves.
- Connect flexible tubing to the test port located between the AFGSOV's and place the open end of the tubing approximately ¼ inch deep in a cup of water.
- Open the test port valve and observe for bubbles in the water. If there are no bubbles in a two-minute time period, the upstream AFGSOV passes the leak test.
- With the boiler off line, close the manual lockable valve on the vent line and the manual valve in the main gas line downstream of the second AFGSOV.

Checklist for Automatic Fuel Gas Shutoff Valves and Solenoid Vent Valve Seat Leakage (AFGSOV & AFGSVV) – Main Gas Line (Continued)

Downstream AFGSOV Leak Test

- Connect flexible tubing to the test port on the main gas line downstream of the second AFGSOV and place the open end of the tubing approximately ¼ inch deep in a cup of water.
- Pressurize the space between the two AFGSOV's to approximately the normal gas pressure by using an air pump with pressure gage connected to the test port between the two AFGSOV's.
- Open the test port valve and observe for bubbles in the water. If there are no bubbles in two minutes, the downstream AFGSOV passes the leak test.

Result	Y/N
Correct Installation?	
Did upstream AFGSOV leak?	
Did downstream AFGSOV leak?	
Did AFGSVV leak?	
Did AFGSVV open with boiler off	

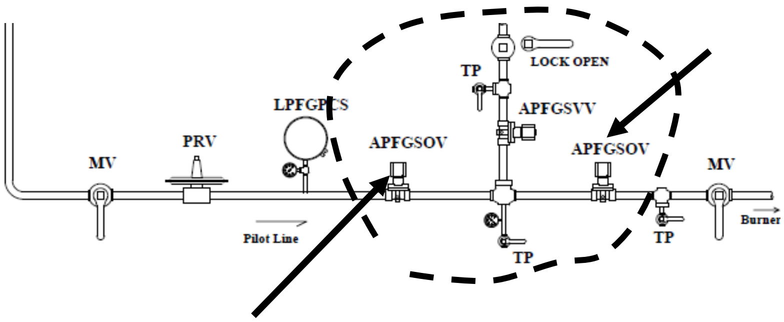
Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail

If boiler is to be operated with failed safety device, a properly approved ISM is required.
Describe safety device failure/remedy in Appendix F.

Checklist for Automatic Pilot Fuel Gas Shutoff Valves and Automatic Pilot Fuel Gas Solenoid Vent Valve Seat Leakage (APFGSOV & APFGSVV) – Pilot Line

Item	Make	Range (inwc/PSIG)
APFGSOV		
APFGSVV		
Pressure Gage		

*Maximum allowable leak rate is zero bubbles in 2 minutes.



Vent Valve Leak Test

- Connect flexible tubing (approximately ¼ inch diameter and approximately 3 feet long) to the test port in the vent line. Place the open end of the flexible tubing approximately ¼ inch deep in a cup of water.
- With the boiler running in low fire, close the manual lockable valve in the vent line and open the test port valve. If no bubbles appear in the water within a two-minute time period, the vent valve passes.

Upstream APFGSOV Leak Test

- Connect a pressure gage to the test port downstream of the two APFGSOV’s and open the test port valve. With the boiler running in low fire, close the manual lockable valve in the vent line and then quickly close the manual valve in the main gas line downstream of the two APFGSOV’s. Observe the pressure gage to make sure the manual valve does not leak. Bleed the pressure by briefly opening and then re-closing both the manual vent valve and the manual main gas line valves.
- Connect flexible tubing to the test port located between the APFGSOV’s and place the open end of the tubing approximately ¼ inch deep in a cup of water.
- Open the test port valve and observe for bubbles in the water. If there are no bubbles in a two-minute time period, the upstream APFGSOV passes the leak test.

Downstream APFGSOV Leak Test

- Connect flexible tubing to the test port on the main gas line downstream of the second APFGSOV and place the open end of the tubing approximately ¼ inch deep in a cup of water.

Checklist for Automatic Pilot Fuel Gas Shutoff Valves and Automatic Pilot Fuel Gas Solenoid Vent Valve Seat Leakage (APFGSOV & APFGSVV) – Pilot Line (Continued)

- Pressurize the space between the two APFGSOV's to approximately the normal gas pressure by using an air pump with pressure gage connected to the test port between the two APFGSOV's.
- Open the test port valve and observe for bubbles in the water. If there are no bubbles in two minutes, the downstream APFGSOV passes the leak test.

Result	Y/N
Correct Installation?	
Did upstream APFGSOV leak?	
Did downstream APFGSOV leak?	
Did APFGSVV leak?	
Did APFGSVV open with boiler off	

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required.
Describe safety device failure/remedy in Appendix F.

Checklist for Proof of Closure on Automatic Fuel Shutoff Valves (POC-AFGSOV) – Natural Gas

Item	Make
POC-AFGSOV	

*Switch is required to open with a very slight opening of the valve (no indicated pressure).
*Switches is required to be wired in series.

- Close manual fuel valve downstream of AFGSOV. Perform the following test on each AFGSOV separately.
- Remove cover on both automatic shut off valves to provide access to two wires connected across proof of closure switch. Can also access wires in appropriate junction box. Disconnect both leads from switch going to control circuit.
- Temporarily connect the two wires that were disconnected from the POC switch in order to electrically bypass the switch.
- Start boiler and verify that switch opens before the AFGSOV opens to the point of allowing flow by measuring resistance across switch. Verifying that switch opens before the AFGSOV opens can be done by measuring pressure downstream of switch. Infinite resistance across the switch should occur before pressure is measured.
- Shut boiler down and disconnect two wires going to control circuit. Try to start boiler and verify that the boiler does not allow ignition sequence to begin.
- Repeat procedure for switch on 2nd valve.

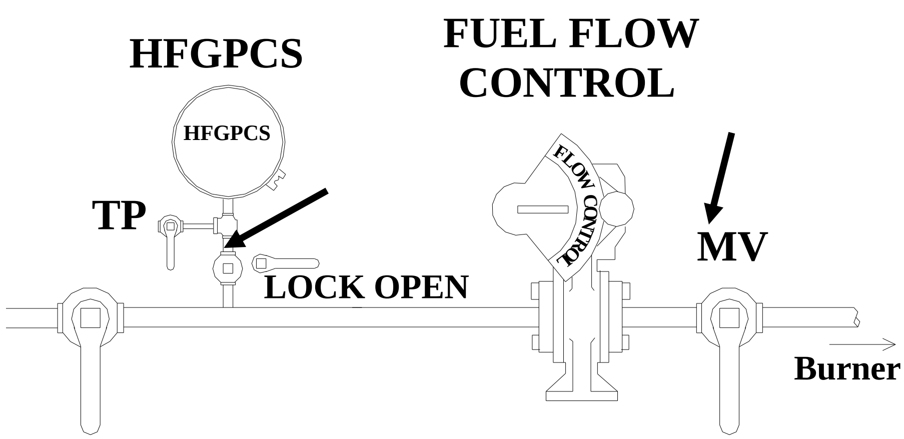
Result	Y/N
Is POC present in both valves wired in series?	
Did either POC being open prevent the boiler from firing?	
Did switch on each AFGSOV open before the AFGSOV opened (no indicated pressure)?	

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required. Describe safety device failure/remedy in Appendix F.

Checklist for Flame Scanner-for main flame out (FSMFO)

Item	Make	Model
Flame Scanner		

*Maximum allowable timing is 4 sec.
*Only a UV– Self checking scanner is VA compliant.
*The scanner is required to not be rebuilt.



- Operate boiler in low fire.
- Close the lockable manual valve between the fuel line and the HFGPCS.
- Quickly close the manual valve in fuel line before burner.
- Observe the time required for the flame scanner to close the automatic fuel gas shutoff valves. (Valves should close within 3 to 4 seconds from the time the flame goes out in the firebox).

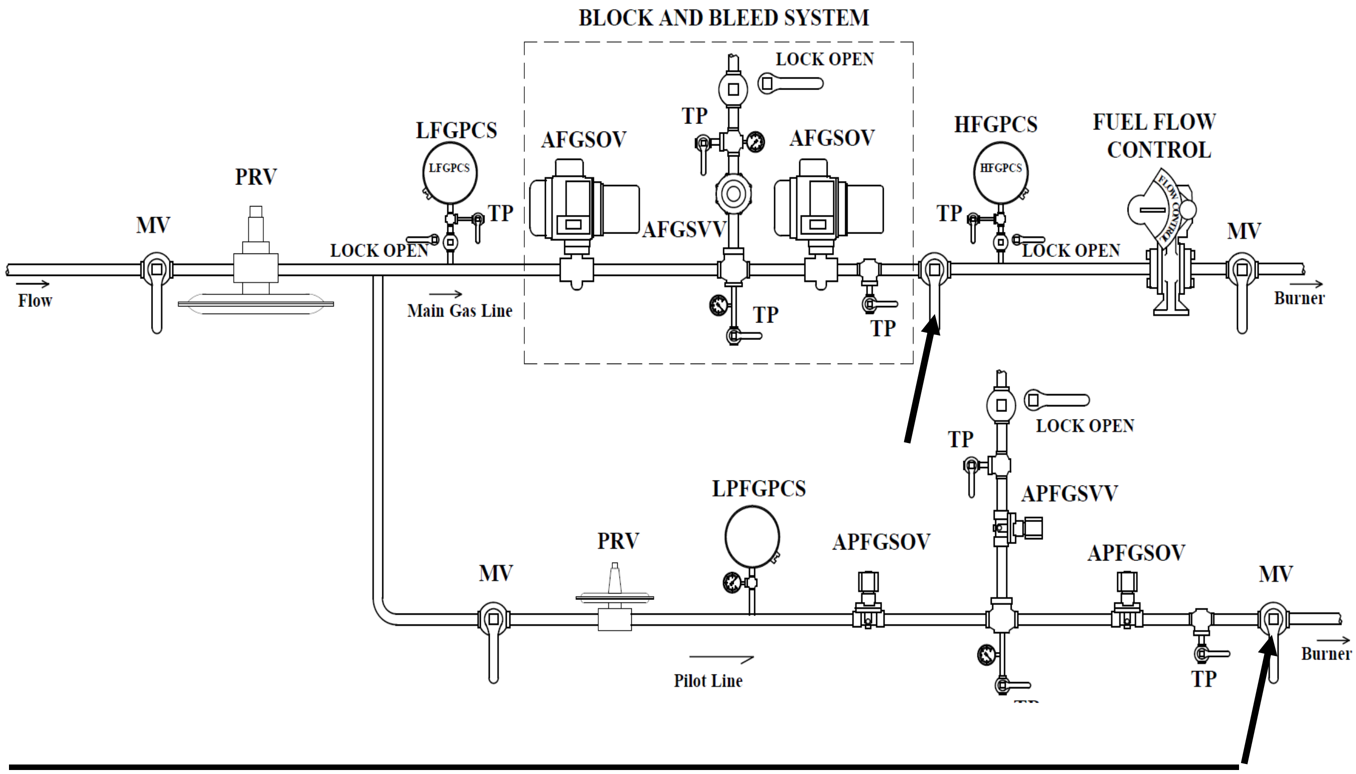
Result	Y/N	Time (seconds)
Is scanner UV, self-checking and not rebuilt?		
Did the scanner work correctly?		
Time to close fuel valves?		

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required. Describe safety device failure/remedy in Appendix F.

Checklist for Flame Scanner Not Sensing Igniter Spark (FSNSIS)

Item	Make	Model
Programmer		

*The scanner is required to not indicate a voltage for duration igniter spark is on, Voltage indicates that scanner senses spark.
*Only a UV– Self checking scanner is VA compliant.
*The scanner is required to not be rebuilt.



- Close manual valve in main fuel line after the second (AFGSOV) and before the HFGPCS and the manual valve in the pilot gas line downstream of the second APFGSOV.
- Attempt to start boiler. The boiler should go through pilot trial for ignition.
- Determine if the scanner output indicates a voltage during pilot trial for ignition.

Result	Y/N
Is scanner UV, self-checking and not rebuilt?	
Did the scanner work correctly?	

Did the device fail or pass the 3 Question Criteria (section 1.3.1)?   Pass   Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required.
Describe safety device failure/remedy in Appendix F.

Checklist for Igniter Timing (IT)

Item	Make	Model
Programmer		

* Maximum allowable duration is 10 sec.

- Close manual valve in main fuel line after the second (AFGSOV) and before the HFGPCS and the manual valve in the pilot gas line downstream of the second APFGSOV.
- Attempt to Start boiler.
- View igniter by means of furnace front or back view port and time the ignition spark. (You can hear the igniter click on and off so that it may not be necessary to view the spark if not easily visible).
- Observe the duration of the ignition spark with a stop watch.

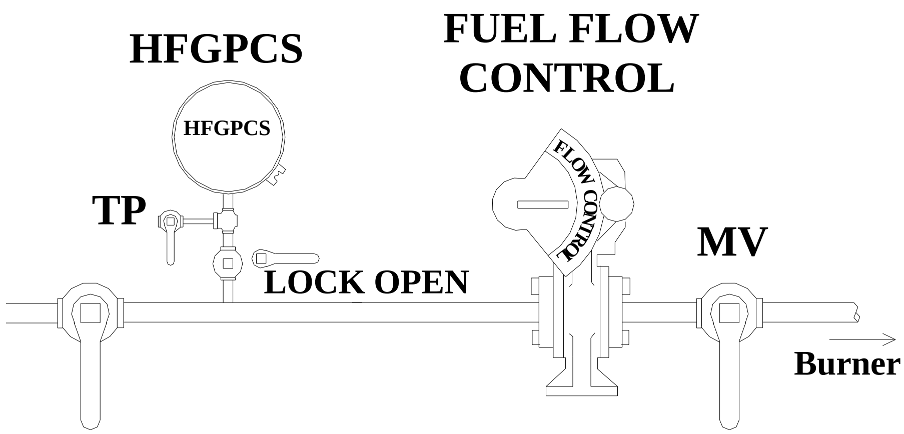
Result	Y/N	Time (seconds)
Did the scanner work correctly?		
Igniter timing?		

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required. Describe safety device failure/remedy in Appendix F.

Checklist for Main Flame Ignition Timing (MFIT)

Item	Make	Model
Programmer		

* Maximum timing is required to be 14 seconds from attempt to start boiler until AFGSOVs close.



- Close the lockable manual valve in the fuel line after the second (AFGSOV) and before the HFGPCS .
- Close manual valves in main fuel line.
- Attempt to start boiler.
- Time the AFGSOV from the time they begin to open until they close with a stopwatch.

Result	Y/N	Time (seconds)
Did the programmer work correctly?		
Time to AFGSOVs?		

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required.
Describe safety device failure/remedy in Appendix F.

Checklist for Pre-Purge and Post-Purge Timing (PPT)

Item	Make	Model
Purge Timer		

Boiler make	Fire Tube / Water tube	Boiler Fireside Volume (ft^3)

* Eight air changes are required for a water tube boiler and 4 air changes for a fire tube boiler.
The method to calculate required purge time is:
Let $V_{fireside}$ = volume of boiler fireside measured in **cubic feet**. (Obtain from boiler manufacturer) = _______________cubic feet

Let m = maximum boiler capacity in lb/hr of steam = __________ lb/hr

Let AC = required air changes (4 for a fire tube boiler and 8 for a water tube boiler) = __________

Then required minimum purge time = (AC x $V_{fireside}$ x 270) / m = ______ sec

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- Start up boiler and record the pre-purge time in the table below.
- Repeat this step for post purge cycle.

Result	Time (sec)	Y/N
Adjustable Timing?		
Low fire to high fire?		
Time in high fire?		
High fire to low fire?		
Time in post purge?		
Equivalent High Purge Time?		
Is purge adequate?		

*Equivalent pre-purge is all time spent at high fire plus half of the time spent in getting to high fire and returning to low fire.

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required.
Describe safety device failure/remedy in Appendix F.

Checklist for Low-Fire Proving Switch (LFPS)

Item	Make	Model
LFPS of gas valve position		
LFPS on oil valve position		
LFPS on forced draft damper		

*The LFPS is required not to be made above 10% of the load range for the actuator monitored by LFPS and to be separate from control system modulating firing rate.

*For single point positioning control systems, only one LFPS is required to determine the position of the fuel flow control valves and air damper. (To use one LFPS for this situation, all linkages to the oil valve and air damper are required to be drilled and pinned. Also if the LFPS is mounted in the drive motor or linkages connecting the drive motor to the LFPS, the linkage to the gas valve must be drilled and pinned.). For parallel positioning systems (with no mechanical connection between the fuel flow control valves and the inlet air damper) a LFPS is required on the gas flow control valve, the oil flow control valve, and the inlet air damper (three switches in all, directly activated by the actuator that is monitored by the LFPS).

*For the case of VFD fan control, this test is valid only if the damper controls air flow at low fire. If this is not the case, an appropriate alternate procedure must be developed and reviewed with CFM/OCAMES prior to operation to ensure an equivalent level of safety.

- Perform the following test for each of the required LFPS.
- Start the boiler and disconnect one electrical lead from switch.
- Measure the ohms across the switch as boiler load is increased. (The switch should be closed at low fire (Less than 2 ohms) and should open with less than a 10% point increase in load for all LFPS).
- Turn boiler off and try to restart boiler with electrical lead disconnected. Boiler should not start. If the boiler does start, the switch is not working correctly.

Result	Y/N	Switch Trip point
Correct switch for all required valve/damper positions?		
Did all the required switches work correctly?		
What was the switch trip point for gas valve position?		
What was the switch trip point for oil valve position?		
What was the switch trip point for the forced draft damper position?		

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail

If boiler is to be operated with failed safety device, a properly approved ISM is required.

Describe safety device failure/remedy in Appendix F.

Checklist for Forced Draft Damper Wide-Open Pre-Purge Proving Switch (FDDWOPS)

Item	Make	Model
FDDWOPS		

* Is required to be open at positions with damper vanes less than 90% wide open.
* If the switch is not actuated by damper itself, all connections in linkages must be drilled and pinned.

- Measure the voltage across the switch during the purge cycle to determine if the switch is open or closed. Note load that switch closes.
- Disconnect one electrical lead from switch. Let boiler go through purge cycle. (Boiler should stay at high purge).

Result	Y/N	% Load that switch closes.
Is switch actuated by damper itself?		
If switch is not actuated by damper itself, are all required connections drilled and pinned?		
Did the switch work correctly? Record % Load.		

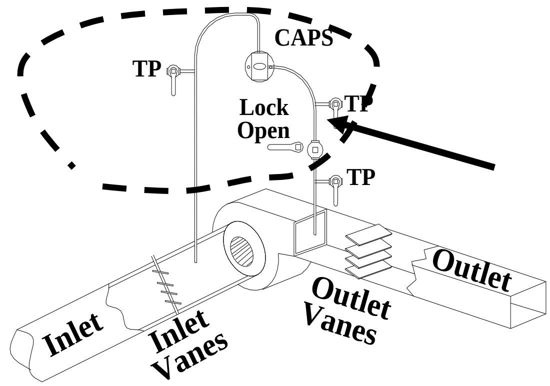
Did the device fail or pass the 3 Question Criteria (section 1.3.1)?   Pass   Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required.
Describe safety device failure/remedy in Appendix F.

Checklist for Combustion Air Pressure Switch (CAPS)

THIS TEST IS APPLICABLE ONLY TO A VARIABLE SPEED FORCED DRAFT FAN SETUP

Item	Make	Low Pressure Tap Location	High Pressure Tap Location	Switch Range (inwc)	Switch Setpoint (inwc)
CAPS					

*CAPS is required to be open if pressure drops to less than 35% of the pressure difference measured at purge. It probably will be necessary to limit the turndown of fan speed to approximately 40 Hertz in order to achieve this requirement.
*Switch taps are required to be across fan with no variable damper between as shown.



- Install appropriate flex tubing to a manometer from the test ports closest to CAPS to measure the pressure difference that the switch senses by opening the lockable test ports across the switch.
- Start the boiler and record the pressure difference read by manometer during purge.
- During purge close the lockable manual valve to isolate high pressure leg of switch or, with boiler running, use a hand pump to pressurize the high pressure leg of switch
- With boiler running, decrease the pressure in the high pressure leg by slowly opening the test port closest to the fan outlet (high pressure leg) and observe the pressure at which the switch opens and shuts off boiler.
- Record value of pressure difference at which switch tripped

	Pressure (inwc)	Y/N
Pressure Difference during purge		
Switch Trip (Break) Point		
Is switch installed correctly?		
Did switch work correctly?		

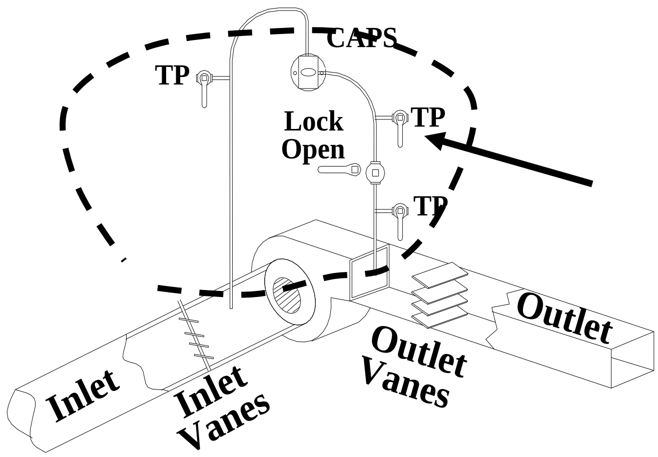
Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required.
Describe safety device failure/remedy in Appendix F.

Checklist for Combustion Air Pressure Switch (CAPS)

THIS TEST IS APPLICABLE ONLY TO A CONSTANT SPEED FORCED DRAFT FAN SETUP

Item	Make	Low Pressure Tap Location	High Pressure Tap Location	Switch Range (inwc)	Switch Setpoint (inwc)
CAPS					

*CAPS should open if pressure drops to 80% of minimum pressure difference.
*Switch taps are required to be across fan with no variable damper between as shown.



- Install appropriate flex tubing to a manometer from the test ports closest to CAPS to measure the pressure difference that the switch senses by opening the lockable test ports across the switch.
- Start the boiler and record the pressure difference read by manometer during purge.
- During purge close the lockable manual valve to isolate high pressure leg of switch (this is easiest way to apply adequate pressure across the switch)
- With boiler running, make the pressure drop in the high pressure leg by slowly opening the test port closest to the fan outlet (high pressure leg) and observe the pressure at which the switch opens and shuts off boiler.
- Record value of pressure difference at which switch tripped.

	Pressure (inwc)	Y/N
Minimum Pressure Difference from low to high fire		
Switch Trip (Break) Point		
Is switch installed correctly?		
Did switch work correctly?		

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required. Describe safety device failure/remedy in Appendix F.

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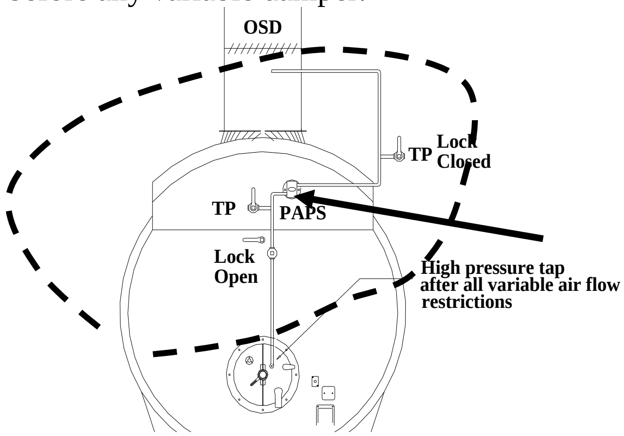
Checklist for Purge Airflow Proving Switch (PAPS)

Item	Make	Low Pressure Tap Location	High Pressure Tap Location	Switch Range (inwc)	Switch Setpoint (inwc)
PAPS					

*PAPS is required to make at 80% or more of maximum differential pressure signal at high fire.
* Switch taps are required to be in inlet to combustion chamber after any variable damper and in the boiler stack before any variable damper.



- Connect a manometer to measure the pressure difference that the switch senses by opening the test ports on either side of the switch and installing appropriate flex tubing to the manometer from the test ports.
- Start the boiler and record the pressure difference indicated by manometer from low fire to high fire positions.
- With boiler offline disconnect one lead from the PAPS.
- Close lock open valve on the high pressure side of the switch and slowly pressurize the high pressure leg with air using a hand pump.
- Determine switch trip point using a manometer and measuring electrical resistance across the switch.
- With lock open valve on high pressure side of switch open and high pressure leg test port open, attempt to restart boiler. Boiler should hold in purge.
- Open lock open valve and close test port. Boiler should light.

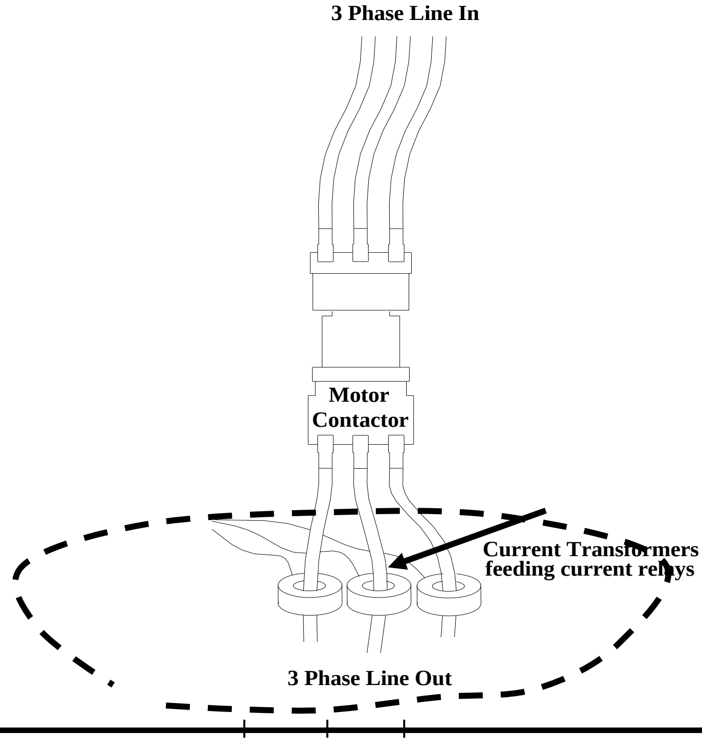
	Pressure (inwc)	Y/N
Maximum Pressure Difference from low to high fire		
Switch Trip (make) Point		
Is switch installed correctly?		
Did switch work correctly?		

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required. Describe safety device failure/remedy in Appendix F.

Checklist for Forced Draft Motor Interlock Switches (FDMIS)

Item	Make	Type of Switch: Aux. Contact Phase Monitor Current Relays
FDMIS		

*The FDMIS are required to be current relays (one on each of the three phase legs) that can be unlatched and removed for testing (split-core, hinged, clamp-on).



- Be certain to follow NFPA 70E requirements as the forced draft power supply has significant shock and potential arc flash.
- With power to fan off, unclamp and remove one current relay from around one power lead feeding the fan. When complete, restore power.
- Attempt to start boiler. Boiler should shut down quickly.
- Replace the current transformer and repeat above process for each of three power leads to fan.

Result	Y/N
Correct switch?	
Did each switch work correctly?	

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required. Describe safety device failure/remedy in Appendix F.

Checklist for Outlet Stack Damper Position Interlock Switch (OSDPI)

Item	Make	Modulating Damper Y/N
OSDI		

*The OSDPI is required to be open if damper is not at least 80% open. For a modulating damper, the OSDPI is required to interrupt purge if the damper is not at least 80%open. For a non-modulating, operable damper, an open OSDPI is required to interrupt purge during the purge cycle or, if the boiler is firing, is required to shut down the boiler.
*In the case where normal boiler operation does not require a non-modulating damper, no OSDPI is required if the damper is welded in the open position.
*The OSDPI can be actuated by the damper itself or, if all linkages between the switch and damper are drilled and pin, it can be located in the drive motor.

- Connect a multi-meter across the switch to measure voltage.
- Start the boiler and monitor voltage across the switch. The switch should be open (no voltage) until the damper opens to 80% or greater of wide open position.
- Stop boiler and turn off power to controls.
- Disconnect one lead from switch. Install jumper with toggle switch in open position. Start boiler. The boiler should not complete purge sequence
- Using a toggle switch momentarily close the toggle switch. Purge should begin counting. Then open toggle switch. Purge should be interrupted.
- Close toggle switch and let boiler begin firing. Open toggle switch and boiler should shut off.
.

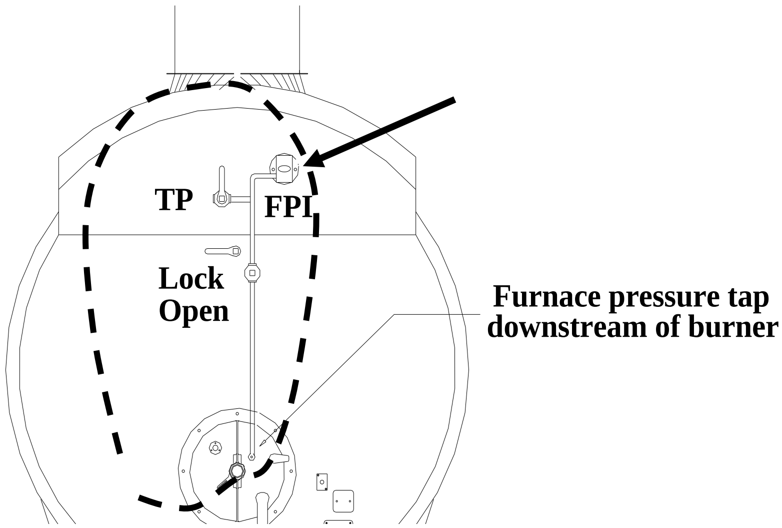
Result	Y/N	Trip Position
If OSDPI is required, is it present?		
If OSDPI is <u>not</u> located on damper itself, are linkages drilled and pinned?		
Did the switch work correctly? Record trip position.		

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required. Describe safety device failure/remedy in Appendix F.

Checklist for Furnace Pressure Interlock (FPI)

Item	Make	Low Pressure Tap Location	High Pressure Tap Location	Switch Setpoint (inwc)
FPI				

*FPI is only required on boilers with a modulating outlet stack damper
*Required trip point is less than the greater of 1 inwc or 120% boiler furnace pressure at high fire.



- Connect a manometer using appropriate flex tubing to the high pressure test port with other side of manometer open to atmosphere. Open TP valve.
- Start the boiler and record the pressure sensed by the switch over the entire firing rate.
- Return the boiler to low fire.
- Close manual lockable valve isolating switch from furnace pressure.
- Connect flex tubing to TP. Tubing must provide means of using a hand pump to pressurize system and a manometer to read the gage pressure.
- Slowly pressurize the switch with the hand air pump.
- Note the pressure that the boiler trips off line.

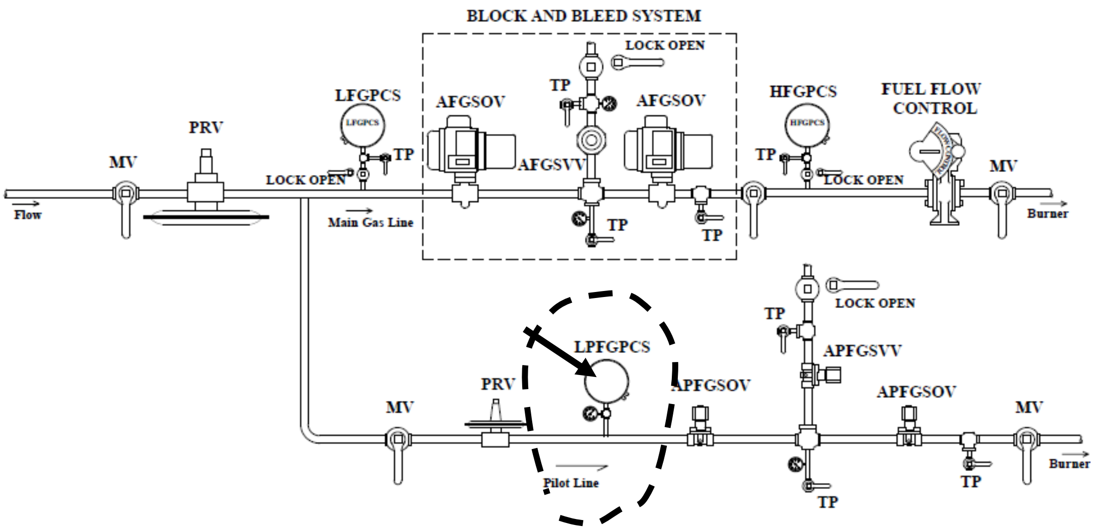
	Pressure (inwc)	Y/N
Maximum Furnace Pressure from low to high fire		
Switch Trip (Break) Point		
Is switch installed correctly?		
Did switch work correctly?		

Did the device fail or pass the 3 Question Criteria (section 1.3.1)?   Pass   Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required.
Describe safety device failure/remedy in Appendix F.

Checklist for Low Pilot Fuel Gas Pressure Cutoff Switch (LPFGPCS)

Item	Make	Range (inwc/psig)	Switch Setpoint	Regulated Pressure
LPFGPCS				
Pressure Gage				

*LPFGPCS Switch setpoint is required to be 80% of regulated pressure and switch is required to be after the PRV as shown. No dampeners, snubbers, or other such devices are allowed.



- Close the manual valve in the gas line after the fuel control valve and allow the pilot burner to light. Place programmer in check mode while holding in the pilot cycle.
- In low fire throttle manual valve upstream of the LPFGPCS slowly until switch trips the boiler offline due to low pilot fuel pressure.
- Open the manual valve upstream of the LPFGPCS and again put boiler in check mode with pilot lit. Slowly close manual valve upstream of the LPFGPCS and regulate the pilot gas pressure to a value of less than 10% above trip point pressure.
- Open the manual valve in the gas line after the fuel control valve, place the programmer in the “run” mode, and carefully observe that the main burner ignites immediately and smoothly.
- Be prepared to stop the burner immediately with E Stop if this does not occur.

Result	Y/N	Switch Trip point
Correct switch location/installation?		
Did the boiler light smoothly with low pilot gas pressure?		

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required. Describe safety device failure/remedy in Appendix F.

Checklist for Flue Gas Recirculation Damper Interlock (FGRDI)

Item	**Make**	**Manufacturer Required FGRDI Position on Purge**
FGRDI		

*Open FGRDI switch is required to prevent completion of the pre purge cycle.
*Dampers are required to be at least 80% open on purge if manufacturer requires an open damper on purge or it should be at least 80% closed if the manufacturer requires a closed damper on purge.
*If manufacturer requires an open damper on purge, consult manufacturer to determine if additional purge time is recommended.
*The FGRDI can be actuated by the damper itself or, if all linkages between the switch and damper are drilled and pinned, it can be located in the drive motor.

- Connect a multi-meter across the switch and measure voltage.
- Start the boiler and monitor voltage across the switch. The switch should be open (voltage present) unless the damper is within acceptable tolerance of required damper position.
- Stop boiler and turn off power to controls.
- Disconnect one lead from switch. Start boiler. The boiler should not complete purge sequence.

Result	**Y/N**	**Load that switch closes.**
Is switch actuated by damper itself?		
If switch is not actuated by damper itself, are all connections drilled and pinned?		
Did the switch work correctly? Record Load.		

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required. Describe safety device failure/remedy in Appendix F.

Checklist for Low Flue Gas Oxygen Level Interlock (LFGOLI)

Item	Make
LFGOLI	

*LFGOLI is required be an alarm and interlock.
*LFGOLI is required to prevent boiler from operating with more than 200 ppm CO or combustibles in the flue gas.

- During the required 6 month tuning of boiler combustion by a qualified individual, this qualified individual must determine the minimum %Oxygen possible to hold the carbon monoxide and combustibles below 200 ppm. This value must consider both oil and gas firing.
- Start the boiler. Supply calibrated test gas through the sensor calibration test port at the minimum % oxygen concentration (determined in the six-month testing) per manufacturer's instructions.
- Verify that the LFGOLI alarms and shuts down the boiler.

Min % Oxygen from 6 month testing	CO at minimum % Oxygen from 6 month testing

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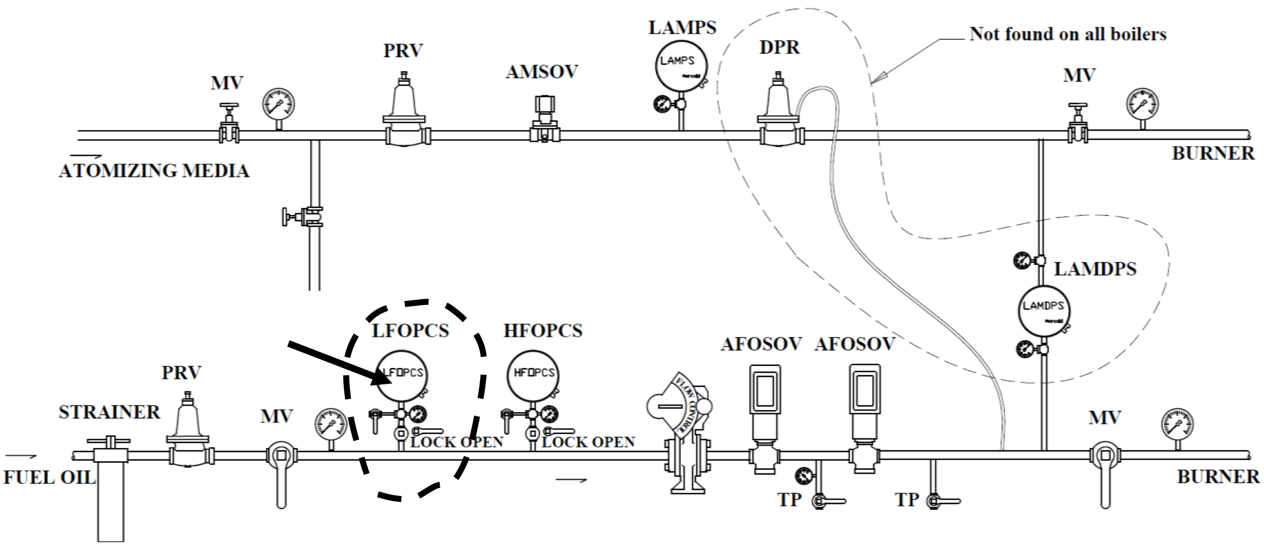
Result	Y/N	Trip point %O_2
Correct Device?		
Did the interlock work correctly? Record %O_2 at trip point.		
Did the LFGOLI activate with less than 200 ppm of CO/Combustibles?		

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required.
Describe safety device failure/remedy in Appendix F.

Checklist for Low Fuel Oil Pressure Cutoff Switch (LFOPCS)

Item	Make	Range (inwc/psig)	Switch Setpoint	Regulated Pressure
LFOPCS				
Pressure Gage				

*The LFOPCS location is required to be downstream of PRV and upstream of flow control valve with test setup shown.
*Trip point of LFOPCS is required to be equal to or greater than 80% of regulated pressure.
* The use of snubbers or dampeners on LFOPCS is prohibited.



- Close lock open manual valve isolating the LFOPCS. Install appropriate tubing on test port. Bleed oil from space between lockable manual valve and LFOPCS into a container for proper disposal.
- Install hand pump or equivalent to the test port capable of supplying air or nitrogen pressure to space. Pressurize the space to above the switch setpoint.
- Start the boiler. At low fire, slowly bleed pressure from the LFOPCS until it trips boiler offline measuring pressure at trip point.

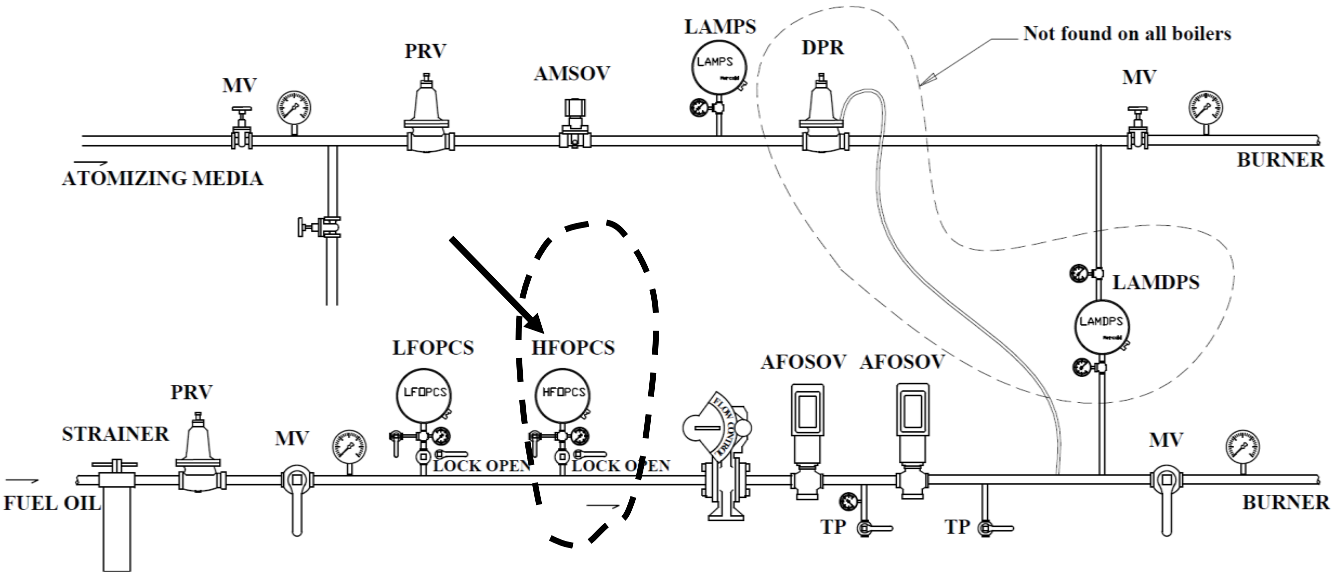
Result	Y/N	Switch Trip point Pressure
Snubber or dampeners **not** used?		
Correct switch location/test setup?		
Did the switch work correctly? Record trip point pressure.		
Is switch setpoint 80% or more of regulated pressure?		

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required.
Describe safety device failure/remedy in Appendix F.

Checklist for High Fuel Oil Pressure Cutoff Switch (HFOPCS)

Item	Make	Range (inwc/psig)	Switch Setpoint	Regulated Pressure
HFOPCS				
Pressure Gage				

*The HFOPCS location is required to be downstream of PRV and upstream of flow control valve with test setup shown.
*Trip point of HFOPCS is required to be equal to or less than 120% of regulated pressure.



- Close lock open manual valve isolating the HFOPCS. Install appropriate tubing on test port. Bleed oil from space between lockable manual valve and HFOPCS into a container for proper disposal.
- Install hand pump or equivalent to the test port capable of supplying air or nitrogen pressure to space. Pressurize the space to above the switch setpoint.
- Start the boiler. At low fire, slowly raise pressure to the HFOPCS until it trips boiler offline measuring pressure at trip point.

Result	Y/N	Switch Trip Point Pressure
Correct switch location/test setup?		
Did the switch work correctly? Record trip point pressure.		
Is switch trip point 120% or less of regulated pressure?		

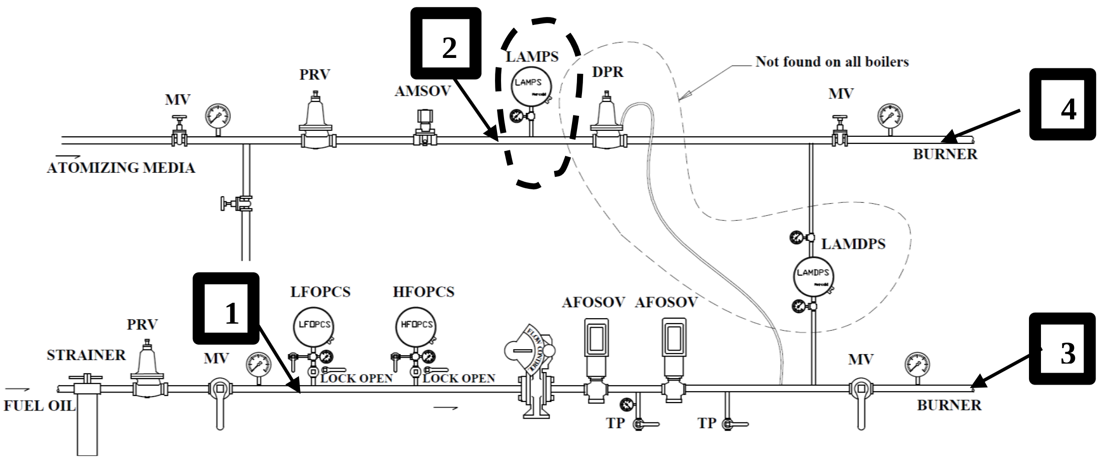
Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required.
Describe safety device failure/remedy in Appendix F.

Checklist for Low Atomizing Media Pressure Switch (LAMPS)

Item	Pressure
Atomizing media pressure at low fire	

Item	Make	Range (inwc/psig)	Switch Setpoint	Regulated Pressure
LAMPS				
Pressure Gage				

*LAMPS setpoint is required to be 80% or more of atomizing media pressure upstream of the LAMPS at low fire



- Operate boiler and determine data in following table.

Item	Minimum Fire (psig)	Mid Fire (psig)	High Fire (psig)
Oil pressure at burner-state 3			
Atomizing Pressure at burner-state 4			
Oil pressure downstream PRV-state 1			
Atomizing pressure downstream PRV-state 2			
Differential Pressure at burner-state 4-state 3			

- In low fire throttle manual valve in atomizing media line before the switch slowly until switch trips the boiler offline due to low atomizing media pressure but NO LOWER THAN 80% OF ATOMIZING MEDIA PRESSURE AT LOW FIRE.

Result	Y/N	Switch Trip Point
Correct switch location?		
Did the switch work correctly? Record trip point pressure.		

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required.
Describe safety device failure/remedy in Appendix F.

Checklist for Low Atomizing Media Differential Pressure Switch (LAMDPS)

Item	Make	Range (inwc/PSIG)	Switch Setpoint	Minimum Diff Pressure
LAMDPS				
Pressure Gage Fuel Oil Burner				
Pressure Gage Atomizing media				

*The VA does not require a LAMPDS if, at some firing rates, the oil pressure is higher than the atomizing pressure (crossover). For crossover, a flow switch is required. If crossover does not occur, the VA required LAMDPS is a differential pressure switch that has the high pressure leg connected downstream of the differential pressure regulator and its low pressure leg in the oil supply line after the fuel flow control valve.

*Setpoint should be 80% or more of minimum differential pressure between oil and atomizing media.

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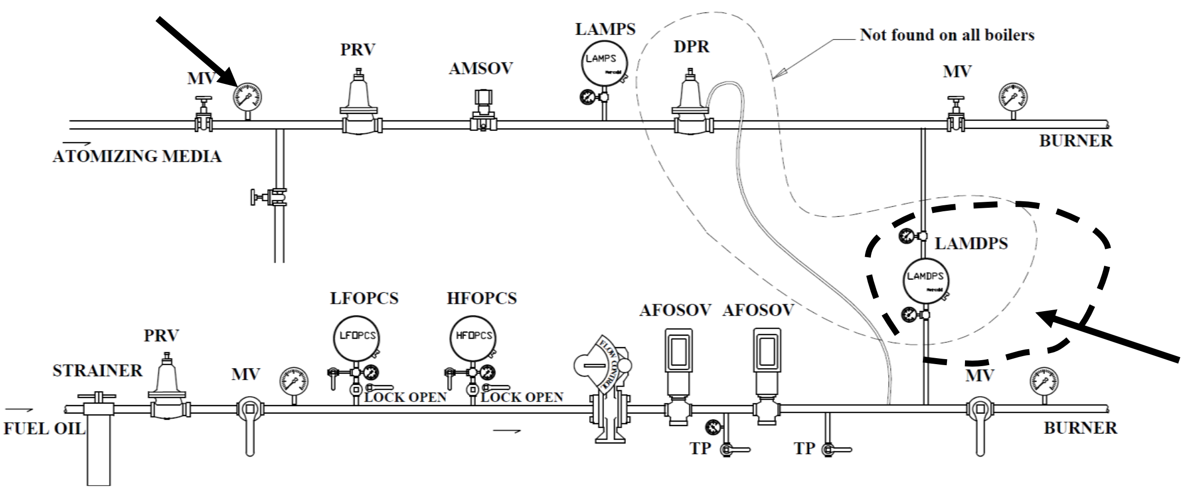


- Determine the minimum differential pressure from data table in LAMPS checklist and record in above table.
- In low fire throttle manual valve in atomizing media line before the LAMDPS slowly until switch trips the boiler offline due to low differential pressure but NO LOWER THAN 80% OF MINIMUM DIFFERENTIAL PRESSURE between oil and atomizing media.

Result	Y/N	Switch Trip point
Correct location/installation?		
Did the switch work correctly? Record Trip Point differential pressure		

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail

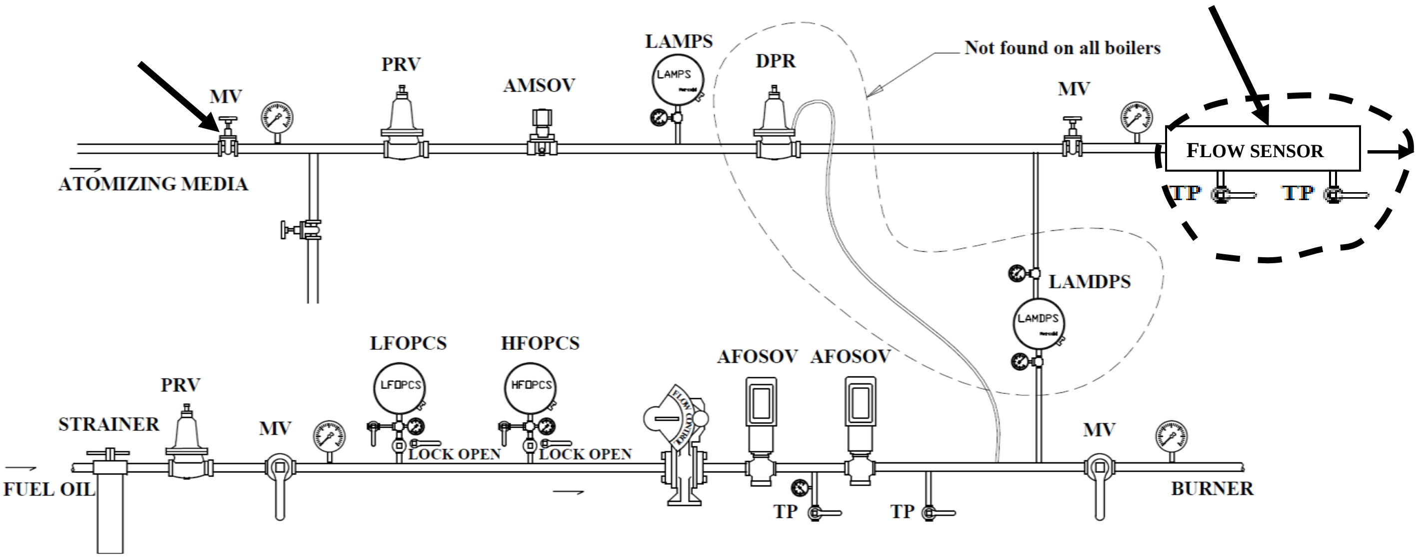
If boiler is to be operated with failed safety device, a properly approved ISM is required. Describe safety device failure/remedy in Appendix F.

Checklist for Low Atomizing Media Flow Switch (LAMFS)

Item	Make	Range (inwc/PSIG)	Switch Setpoint	Minimum Diff Pressure
LAMFS				

*The VA does not require a LAMFS if, at all firing rates, the oil pressure is lower than the atomizing pressure (no crossover) or if the system does not utilize a differential pressure regulator. The VA required LAMFS is a flow switch that is in the atomizing media line downstream of the differential pressure regulator (if it exists) and atomizing media pressure gage.

*Setpoint should be more than 80% of the minimum pressure drop across the flow sensor.



- Measure the pressure drop across the flow sensor at purge, low fire, and high fire. Record the minimum pressure in table above
- In low fire throttle manual valve in atomizing media line before the LAMFS slowly until switch trips the boiler offline due to low differential pressure but NO LOWER THAN 80% OF MINIMUM LAMPS DIFFERENTIAL PRESSURE.

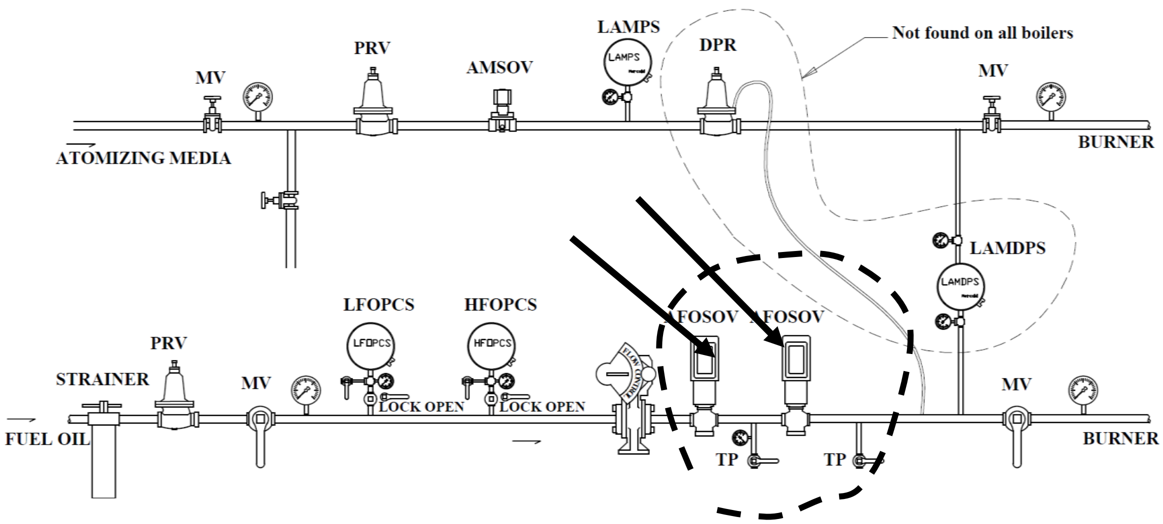
Result	Y/N	Switch Trip Point Pressure
Correct Location/installation?		
Did the switch work correctly? Record trip point pressure.		

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required. Describe safety device failure/remedy in Appendix F.

Checklist for Automatic Fuel Oil Shutoff Valves (AFOSV) - for Seat Leakage

Item	Make	Range (inwc/psig)
AFOSV		
Pressure Gage		

*After drip rate is steady, leak rate is required to be less than one drop in 10 seconds.



- While the boiler is firing quickly close the manual valve in oil line located after the automatic shut off valves.
- Place a container under the test port downstream of both automatic shut off valves. Open the test port valve and observe oil flow. In order to consider the valve as not leaking, oil flow should be less than 1 drop in 10 seconds. Some time is needed to establish a steady drip rate. Make sure that the pressure gage between the 2 auto shut off valves indicates pressure approximately equal to regulated pressure or higher.
- Place a container under the test port between the automatic shut off valves. Open the downstream test port valve between the automatic shut off valves and observe oil flow. In order to consider the valve as not leaking, oil flow should be less than 1 drop in 10 seconds. Some time is needed to establish a steady drip rate.
- Some manufacturers use a vent line between the two AFOSOV's (not required and not shown). If the valve in this vent line is leaking and the two AFOSOV's are not leaking, the pressure between the two AFOSOV's will fall.

Result	Y/N
Did upstream AFOSV leak?	
Did downstream AFOSF leak?	

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required. Describe safety device failure/remedy in Appendix F.

Checklist for Proof of Closure on Automatic Fuel Oil Shutoff Valves (POC-AFOSV) – Oil

Item	Make
POC-AFOSV	

*Switch should open with a very slight opening of the valve.
*Switches on the two valves must be wired in series.

- Close manual fuel valve downstream of both AFOSOV. Perform the following test on each AFOSOV separately.
- Remove cover on both automatic shut off valves to provide access to two wires connected across proof of closure switch. Can also access wires in appropriate junction box. Disconnect both leads from switch going to control circuit.
- Temporarily connect the two wires that were disconnected from the POC switch in order to electrically bypass the switch.
- Start boiler and verify that switch opens before the AFOSOV opens to the point of allowing flow by measuring voltage across switch. Verifying that switch opens before the AFOSOV opens can be done by measuring pressure downstream of switch. Infinite resistance across the switch should occur before pressure is measured.
- Shut boiler down and disconnect the two wires going to control circuit. Try to start boiler and verify that the boiler does not allow ignition sequence to begin.
- Repeat procedure for switch on 2nd valve.
- .

Result	Y/N
Is proof of closure present in both valves wired in series?	
Did either valve being open allow the boiler to fire?	
Did switch on each AFOSOV open with a very slight opening of AFOSOV?	

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required.
Describe safety device failure/remedy in Appendix F.

Checklist for Oil Burner Position Switch (OBPS)

Item	Make
OBPS	

*If no switch is present this test is not required and test is complete.

- Retract the gun enough to disengage the switch. Attempt to start the boiler. The boiler controls should not allow the purge process to begin. IF BOILER BEGINS TO MOVE TO THE PURGE POSTION, SHUT THE BOILER DOWN IMMEDIATELY. IN THIS CASE THE OBPS SWITCH IS DEFECTIVE.

Result	Y/N
Did the switch work correctly?	

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required.
Describe safety device failure/remedy in Appendix F.

Checklist for Emergency Stop/Panic Buttons (ESPB)

*A ESPB is required at each egress point from the plant or boiler room and in the control room.
*Signage to identify the purpose of the ESPB is required.
*The ESPB is required to be protected from accidental activation.
*The ESPB is required to close the natural gas shutoff valve to the plant and de-energize all fuel oil pumps within 3 seconds of activation.
*All ESPB's are required to be tested annually.

- Perform the following test <u>for each</u> of the required ESPB. (Perform test when a short steam outage will not deleteriously affect hospital operation.)
- Turn on fuel oil pumps.
- Fire one boiler on natural gas.
- Have an observer present at the natural gas shutoff valve to the plant and a second observer at the fuel oil pumps
- Activate the ESPB.
- Verify that the natural gas shut off valve to the plant closes within 3 seconds.
- Verify that the fuel oil pumps shut off within 3 seconds.

Result	**Y/N**
Are ESPB present at each egress point from plant or boiler room and in the control room?	
Is proper signage to identify the purpose of the ESPB present at the location of each ESPB?	
Are all ESPB protected from accidental activation?	
Did all ESPB shut off main gas valve to plant within 3 seconds?	
Did all ESPB shut off the fuel oil pumps within 3 seconds?	
Did all the required switches work correctly?	

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, a properly approved ISM is required.
Describe safety device failure/remedy in Appendix F.

APPENDIX B. ADDITIONAL SAFETY DEVICE TEST PROCEDURES FOR HOT WATER BOILERS

Appendix B.1 INTRODUCTION

Appendix B presents step by step test procedures for safety devices that are specific to hot water boilers. The appendix provides forms for obtaining and recording all necessary data for each safety device being tested. <u>This Appendix is a supplement to Appendix A to be used in testing a hot water boiler. The basic information required in section A.3.3 and certification required in section A.3.4 must be included in the report of safety testing for a hot water boiler in order for the report to be VA compliant.</u>

The assumptions for the test procedures given in this Appendix are first listed. This information is then followed by one sheet for each device being tested to be used by the testing agency personnel as a check list and data form. These procedures must be made site specific to be in compliance with VA requirements. It is very important that all data required in these procedures are taken each time a test is made. Forms that contain pre-filled data lead to mistakes. Also it is important not to use a "check list form" because a reviewer cannot verify that the test has been done correctly due to absence of data.

Appendix B.2. ASSUMPTIONS FOR TEST PROCEDURE

The test procedures in Appendix B makes certain assumptions that are listed below. **PLEASE NOTE THAT THESE ITEMS ARE NOT ALWAYS REPEATED IN EACH TEST PROCEDURE BUT APPLY TO ALL TESTS.**

- After each test, equipment should be returned to normal operating condition and the boiler should be fired to confirm its operability.
- "Jumping" means disabling the switch electrically
- Any electric "jumper" application requires that all power to the device being "jumped" be shut off and only personnel that are trained and qualified to the correct level by NFPA 70E perform such tests.
- Pressure gages used in a test must be calibrated within prior 6 months.
- The set point is the value at which the safety device indicator is set. The trip point is the actual value at which the safety device activates. Some language used in the test procedures assumes that the set point equals the trip point.

Checklist for Low Water Cutouts (LWCOHW and ALWCOHW)

Item	Manufacturer	Probe Y/N	Manufacturer Minimum Water Level, inches	Sight Glass in External Water Column (Y/N)
LWCOHW				

*One probe water level cutout is required (LWCOHW). The probe must require manual reset to operate boiler. A visible water level indicator is required in the external water column and the manufacturer minimum specified water level should be at least 1 inch above the bottom of the sight glass. Note: Some boilers may be fitted with a second auxiliary low water cutoff (ALWCOHW). If present, the ALWCOHW must be tested.

*The probes set points should activate at or above the minimum water level specified by manufacturer and must provide an alarm for LWCOHW and ALWCOHW (if present).

*Isolation valves to isolate the inlet and exit water flow to and from the boiler are required and must be lock open only. Plumbing to allow drain of boiler water that meets local code is required. A manual vent valve communicating between the water in the boiler and the external ambient air is required to allow draining and filling of the boiler without creating a vacuum.

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1. Start the test with the boiler water at near ambient temperature
2. Flush the sight glass to insure communication with the boiler.
3. Close the inlet and exit isolation valves and open manual vent valve
4, Open the manual vent valve.
5. Electrically by-pass the flow switch with a jumper and operate the boiler in low fire.
6. Slowly drain the boiler water. Don't allow water to leave sight glass.
7. Note the water level at which the LWCOHW activates and make sure boiler does not automatically restart. Note whether LWCOHW provided an alarm.
8. If an auxiliary low water cut out exists, electrically bypass the LWCOHW and continue draining water. Do not allow water to leave sight glass.
9. Note the water level at which the ALWCOHW activates. Make sure the boiler does not automatically restart. Note whether the ALWCOHW provided an alarm.
10. Remove jumpers on LWCOHW and flow switch. Fill boiler with treated water. Open isolation valves and close manual vent valve. Restart boiler to insure it is operational.

Result	Y/N	Water Level
Correct installation?		
Did the LWCOHW work correctly including alarm? Record Level.		
If present, did ALWCOHW work correctly including alarm? Record Level.		
Did the LWCOHW & ALWCOHW if present require manual reset?		
Was water level visible in sight glass and more than 1 inch above bottom of sight glass at activation point?		

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail

If boiler is to be operated with failed safety device, a properly approved ISM is required. Describe safety device failure/remedy in Appendix F.

Checklist for Liquid Relief Valves (LRVHW)

Item	Make	Capacity (gal/hr)	Range	Set point psig	Normal Boiler Pressure, psig
Liquid Relief Valve, LRVHW					
Pressure Gage					

Item	Make	MAWP, psig
Boiler		

***One liquid relief valve stamped with an ASME certification must be installed on the boiler. The LRVHW must be plumbed to drain to sewer while meeting local codes for sewer drain conditions. The drain line must be hard piped with a diameter equal to or greater than the outlet diameter of the LRVHW. A view port or other means to determine when the LRVHW opens must be available as well as a test port for connecting a hydrostatic test pump.
*The activation point of the LRVHW must be above normal boiler operating pressure and below the maximum allowable working pressure of boiler. The LRVHW must activate within +/-5% of set value or +/-2 psi whichever is higher.
*LOO Isolation valves must be in place to isolate the incoming and exit water flow to and from boiler.

- With boiler offline close manual valves on inlet and exit water flow to isolate boiler. Use hydrostatic test pump to raise pressure in the boiler and open LRVHW. Note the pressure at which the LRVHW opens. DO NOT RAISE PRESSURE MORE THAN MAXIMUM ALLOWABLE BOILER PRESSURE!
- Open the two isolation valves, disconnect the hydrostatic pump and verify that the boiler is operational and that the LRVHW reseated.

Result	Y/N	Pressure, psig
Correct installation?		
Did the LRVHW work correctly?		
What was the lift pressure for the LRVHW?		
Did the LRVHW reseat?		
View port or other means in place to view water flow thru relief valve and proper venting line and conditions?		
Drain line proper?		

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, is a properly approved ISM in place?
Describe safety device failure/remedy in Appendix F.

Checklist for High Water Temperature Switch (HWTS)

Item	Make	Set point F	Normal Boiler Temperature, F	Manufacturer Recommended Maximum Allowable Temperature, F
High Water Temperature Switch				

*A switch mounted high in the boiler near the boiler water outlet to cutout the boiler in case of excessive temperature. The device must be separate from any device used to control temperature.

*The switch set point for shutting down the boiler should be no higher than 15 F above the normal boiler temperature and lower than the recommended maximum temperature set by manufacturer.

*LOO Isolation valves must be in place to isolate the incoming and exit water flow to and from boiler. The boiler must be fitted with a temperature readout that measures the internal water temperature near boiler outlet

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1. This test should only be performed after the LRVHW has been tested and shown to Pass the 3 question Criteria .
2. With boiler running, use an auxiliary means such as a contact thermometer to verify that the temperature readout on boiler water is accurate as compared to the auxiliary reading taken externally on the boiler water outlet. (An alternate approach is to use a recent calibration of the boiler water temperature readout.) Proceed only if the boiler water temperature reading is known to be accurate.
3. Shut the boiler down and close the inlet and exit isolation valves and electrically by pass the flow switch
4. Fire the boiler and slowly raise the water temperature. NEVER ALLOW THE WATER TEMPERATURE TO REACH THE MAXIMUM ALLOWABLE TEMPERATURE PROVIDED BY MANFACTURER!
6. Note the temperature at which the switch shuts down the boiler.
7. Remove flow switch jumper, open isolation valves, and verify the boiler is operational.

Result	Y/N	Switch Trip Point, F
Switch has correct location and is independent of		
Did switch work correctly? Record Temperature		
Is switch trip point correct?		

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, is a properly approved ISM in place? Describe safety device failure/remedy in Appendix F.

Checklist for Flow Switch (FS)

Item	Make	Minimum Flow required by boiler manufacturer, gpm
Flow Switch		

*A flow switch that is normally open and activates without a delay is required.
*The set point flow rate for the FS for shutting down the boiler should be 10% or more above the manufacturer's required minimum flow.
*A method to measure flow of water through the boiler is required, such as a strap on flow meter or equivalent.

---

1. With the boiler in low fire, use the inlet or exit isolation valve to slowly throttle the flow of water through the boiler. (If a VFD pump control is available, it is preferable to place the VFD in manual and use the VFD control to slow the water flow rather than throttling the water with a valve.)
2. Monitor the water temperature to be sure it does not exceed the manufacturer's maximum allowable temperature.
3. Observe the flow rate that causes the boiler to trip off line due to low flow.
4. Open the isolation valve used to throttle the flow (or place VFD in automatic) and start boiler to prove operable.

Result	Y/N	Flow Rate, gpm
Correct installation including non-adjustable set point?		
Did the FS work correctly?		
What was the trip point flow rate for the FS?		

Did the device fail or pass the 3 Question Criteria (section 1.3.1)? Pass Fail
If boiler is to be operated with failed safety device, is a properly approved ISM in place?
Describe safety device failure/remedy in Appendix F.

APPENDIX C. WATER TREATMENT CHECKLISTS

Poor water treatment leads to scale and corrosion which obviously impacts safety. Of course, poor water treatment detrimentally affects efficiency, decreases equipment life, decreases reliability, and increases the cost of maintenance. Provide following data:

Type of Softener (circle): None Ion exchange Reverse Osmosis

Provide Location for Feeding:

Phosphate/polymer__________ Sulfite_____________ Amines____________

How many times per day do you do mud blowdown? ____________

In Table C.1 record the control range specified by chemical vendor in spaces provided.

Table C.1 Chemical Vendor Control Ranges for Water Quality Parameters

		SAMPLE LOCATION			
		Boiler	**Feedwater**	**Condensate**	**Makeup**
PROPERTY	**TDS, micromhos/cm**				
	Sulfite, ppm				
	Phosphate or polymer, ppm				
	Total Alkalinity, ppm				
	Hardness, ppm				
	pH				
	Iron, ppm				

In Table C.2 estimate the percentage of time that parameters are actually within control range. Base the answers on data taken over the last 6 months.

Table C.2 Percent Time in Compliance Within Control Range

		SAMPLE LOCATION			
		Boiler	**Feedwater**	**Condensate**	**Makeup**
PROPERTY	**TDS, micromhos/cm**				
	Sulfite, ppm				
	Phosphate or polymer, ppm				
	Total Alkalinity, ppm				
	Hardness, ppm				
	pH				
	Iron, ppm				

Based on Table C.1, Calculate the blowdown percentage and makeup percentage using following formulas:

$$\%Makeup = \frac{Conductivity\_of\_Feedwater - Conductivity\_of\_Condensate}{Conductivity\_of\_MU - Conductivity\_of\_Condensate} * 100$$

=________%

$$\%Blowdown = \frac{Conductivity\_of\_Feedwater}{Conductivity\_of\_Boiler - Conductivity\_of\_Feedwater} * 100$$

= ________%

ANSWER THE FOLLOWING QUESTIONS: Pass Fail

Is your makeup less than 10%?..YES OR NO
Is your blowdown less than 1%?..YES OR NO
Overall were your all water quality parameters in compliance with specified ranges more than 90%? of time? ....YES OR NO
Was the iron in your condensate less than .1 ppm more than 99% of time?..YES OR NO
Was the hardness leaving the softener = 0 more than 99% of time?...........YES OR NO
Is hardness in the condensate = 0 more than 99% of time?....................... YES OR NO
Is the TDS in your boiler more than 3500 micro mhos/cm more than 90% of time?..YES OR NO
Do you do mud blowdown **only** on actively fired boilers?............................YES OR NO
Do you do mud blowdown no more than once per day? ....YES OR NO
Are chemicals fed continuously?..YES OR NO
Do you use Continuous Blowdown as primary means to control TDS? ....YES OR NO
*Do you feed phosphate/polymer in feed water or boiler?............................YES OR NO
*Do you feed the sulfite in the sump of the deaerator? ....YES OR NO
*Do you feed amines in the boiler or steam lines? ....YES OR NO
Does your chemical vendor regularly measure pH in condensate at remote locations in order to determine the desirable blend of amines?..........YES OR NO

See Figure C.1 for chemical feed system diagram

While an answer of "NO" to any of above questions does not necessarily mean that you are out of compliance with VA requirements, it is a very strong indication that your water treatment program can be improved in regard to safety, reliability, maintenance costs, and efficiency.

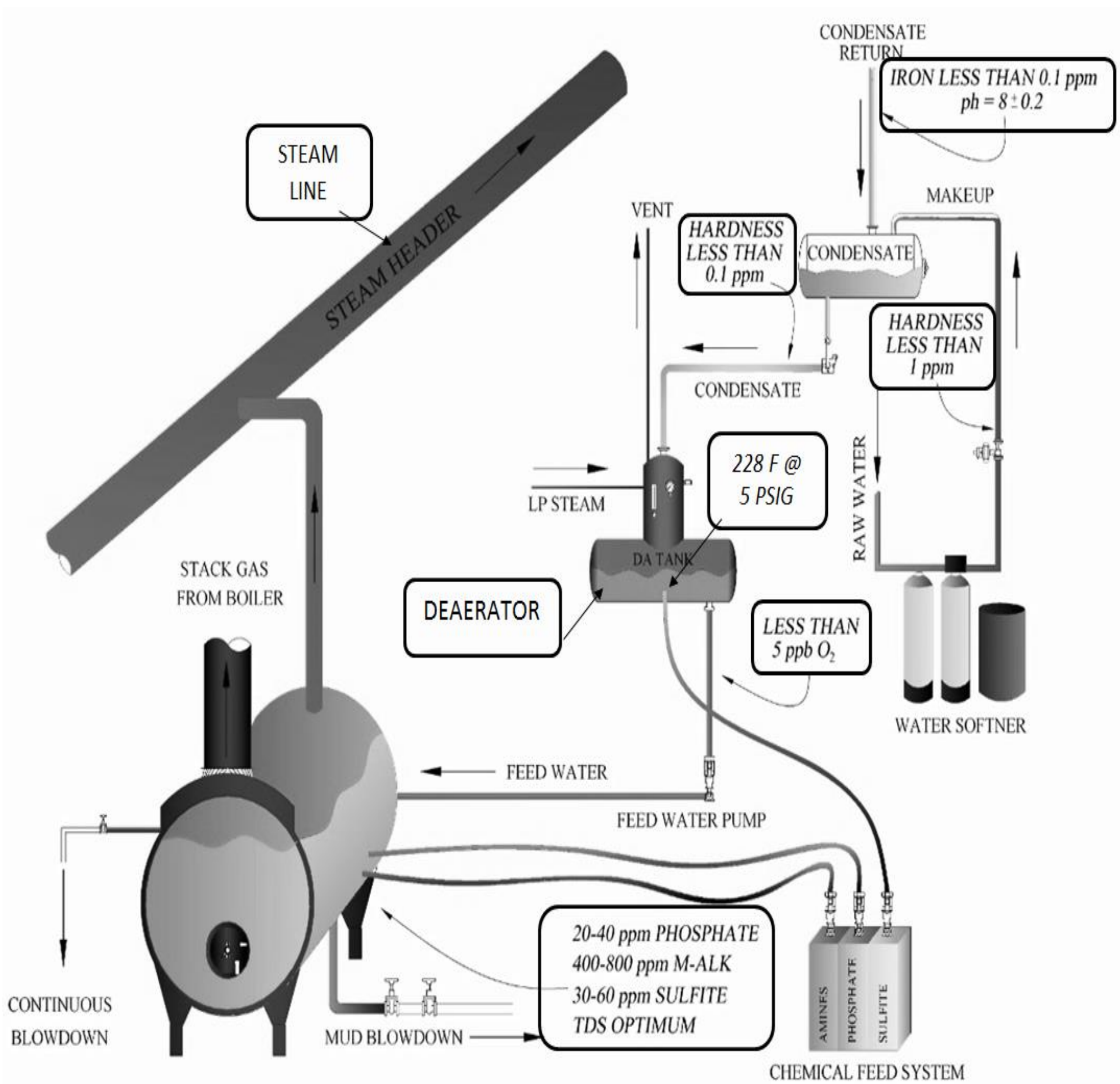

Figure C.1 Chemical Feed System Diagram

APPENDIX D. CHECKLIST FOR GENERAL PLANT SAFETY AND RELIABILITY

Most of the questions below are related to reliability. However, a decrease in reliability inevitably leads to increased safety risk.

The following questions must be answered based on actual experience and knowledge.

RESULTS: CIRCLE ANSWER PASS FAIL

1. Is there a deaerator tank bypass? .... YES OR NO
2. Is there a condensate tank bypass? .... YES OR NO
3. Is there a softener bypass? ....YES OR NO
4. Is there auxiliary makeup to deaerator? ....YES OR NO
5. Is there an adequate supply of emergency water available for boilers? .... YES OR NO
6. Is there a high oil alarm on oil tanks? ....YES OR NO
7. Is there a high gas pressure cutout on main gas line entering boiler? ....YES OR NO
8. Is there an emergency kill switch (**oil and gas**) in office and all points of egress?..YES OR NO

APPENDIX E. TYPICAL EQUIPMENT USED IN BOILER SAFETY TESTING

Note:

1. This list is not intended to promote a particular item or vendor. Other comparable products and vendors are available. The user must verify any required chemical compatibility and specification/rating for the intended use of the item.

2. Numbers appearing in bold and underlined after an item are McMaster Carr numbers

TOOLS

Greenlee 56341 Heavy-Duty 4 Pocket Leather Pouch

GB GS-385 6-1/2-Inch Long Nose Electrical Plier with Cutter and Crimper

Tongue and Groove Pliers - 6" - 426, by Channellock

Klein Tools 11045 Flat Design Wire Stripper-Cutter for 10-18 AWG Solid Wire

Klein 5-in-1 Screwdriver/Nut Driver - 32476

DORCY 41-4260 1 WATT- 3AAA LED ALUMINUM FLASHLIGHT W/ BATTERIES

12" pipe wrench

6" pipe wrench

Crescent Adjustable Wrench with Cushioned Grip 6 Inch

Klein Tools 85071 2-Piece Stubby Cushion-grip Screwdriver

6 PC SCREWDRIVER SET Stanley Model: 66-052

Craftsman 3 pc. Screwdriver Set, Finger Bit Item# 00941390000 Model# 41390

Greenlee 55482 9 Piece Folding, Ball-End, Hex-Key Wrench Set (0254-12)

Test Cord With Alligator Clips, 8 Ft, 16 Gauge, 2 Conductor, 13 Amp, 300 Volt

Probe Master DMM Test Lead Kit, Softie, Standard Banana

Fluke 114 Electrical Multimeter

Fluke TPAK Meter Hanging Kit

C25, Soft Case For Fluke-25/27/8025a

Testo 510 Differential Pressure Manometer OR Dwyer Instruments 475-2

ACCUSPLIT AX605 Event Stopwatch

Military Grade Pipe Thread Sealant Tape Premium, 43' Length X 1/2" Width, Light Yellow

44945K35

electrical tape

Greenlee GT-12 Non-Contact Voltage Detector

Toggle switch with test leads (Lowes Serv-A-Lite Double Pole Insulated Switch Item #: 75706 Model: 91086U)

PATCH CORD, INSULATED ALLIGATOR CLIP ON EACH END, 24"L, RED (jumpers)
6927K34

TEST GAGES (THE GAGES LISTED ARE ASHCROFT)

XB1 BOOT (protective rubber boot)

25-D1005PS-02L-300# (0-300psi)

25D1005PS-02l (0-30 psi)

25D1005PS-02l (0-60 psi)

FITTINGS (NPT)

Brass reducing bushing 3/4 x ½	**4429k414**
Brass reducing bushing 1/2 x 3/8	**4429k413**
Brass reducing bushing 3/8 x ¼	**4429k412**
Brass reducing bushing 1/4 x 1/8	**4429k411**
Brass coupling 1/4 x ¼	**4978k132**
Brass coupling 3/8 x 3/8	**9162k313**
Iron coupling 1/2 x ½	**4638k114**

CONNECTORS (PUSH TO CONNECT)

Nickel-Plated Brass Push-to-Connect Tube Fitting Adapter for 1/4" Tube OD X 1/4" NPT Female Pipe **51495K264**

Nickel-Plated Brass Push-to-Connect Tube Fitting Adapter for 1/4" Tube OD X 1/4" NPTF Male Pipe **51495K191**

Moisture-Resistant Acetyl Push-to-Connect Barb-to-Stem Coupling for 3/16" Tube ID X 1/4" Stem OD **51055K57**

White Polypropylene Push-to-Conn Tube Fitting Tee for 1/4" Tube OD **9087K81**

High-Pressure Polyethylene Vacuum Tubing .17" ID, 1/4" OD, .04" Wall Thickness, White **50375K43**

SOFT TUBING

Super Soft Latex Rubber Tubing 1/2" ID, 5/8" OD, 1/16" Wall, Opaque Black
5234K262

Super Soft Latex Rubber Tubing 3/8" ID, 1/2" OD, 1/16" Wall, Opaque Black
5234K81

Super Soft Latex Rubber Tubing 1/4" ID, 3/8" OD, 1/16" Wall Opaque Black
5234K74

Super Soft Latex Rubber Tubing 1/8" ID, 1/4" OD, 1/16" Wall, Opaque Black
5234K71

SEMI-SOFT TUBING

High-Temperature Silicone Rubber Tubing Firm, 1/2" ID, 5/8" OD, 1/16" Wall, White
51135K84

High-Temperature Silicone Rubber Tubing Firm, 3/8" ID, 1/2" OD, 1/16" Wall, White
51135K82

High-Temperature Silicone Rubber Tubing Firm, 1/4" ID, 3/8" OD, 1/16" Wall, White
51135K77

High-Temperature Silicone Rubber Tubing Firm, 1/8" ID, 1/4" OD, 1/16" Wall, White
51135K73

TUBING COUPLING

Durable Nylon Single-Barbed Tube Fitting Reducing Coupling for 1/4" X 1/8" Tube ID, Black **5463K149**

Durable Nylon Single-Barbed Tube Fitting Reducing Coupling for 3/8" X 1/4" Tube ID, Black **5463K221**

Durable Nylon Single-Barbed Tube Fitting Reducing Coupling for 1/2" X 3/8" Tube ID, Black **5463K225**

APPENDIX F. COMMENTS ON EACH INDIVIDUAL SAFETY TEST

Use the spaces below each test title to discuss the test results.

High Water Alarm on Condensate Tank (HWACT)

Low Water Alarm on Condensate Tank (LWACT)

High Water Alarm on Deaerator Tank (HWADT)

Low Water Alarm on Deaerator Tank (LWADT)

Deaerator Overflow Drain System (DAODS)

Deaerator Safety Valve (DASV)

Safety Valve Following PRV (SVFPRV) – Deaerator

Safety Valve Following PRV (SVFPRV) – Other

Liquid Relief Valve on Oil Pump Set (LRVOPS)

Liquid Relief Valve on Economizer (LRVE)

Control Air Pressure Interlock (CAPI)

Propane Pilot Backup System

Carbon Monoxide and Combustible Gas Alarms in the Boiler Plant

Outside Air Damper Alarm (OADA)

Low Water Alarm and Cutoffs on Boiler (LWA/LWCO/ALWCO)

High Water Alarm on Boiler (HWAB)

Recycle/Non-Recycle Boiler Steam Pressure Limit Switches (RBSPLS & NRBPLS)

Steam Safety Valves on Boiler (SVB)

Low Fuel Gas Pressure Cutoff Switch (LFGPCS)

High Fuel Gas Pressure Cutoff Switch (HFGPCS)

Automatic Fuel Gas Shutoff Valves and Solenoid Vent Valve Seat Leakage (AFGSOV & AFGSVV) - Main Gas

Automatic Pilot Fuel Gas Shutoff Valves and Solenoid Vent Valve Seat Leakage (APFGSOV & APFGSVV) – Pilot Line

Proof of Closure on Automatic Fuel Shutoff Valves (POC-AFGSOV)- Natural Gas

Flame Scanner-for main flame out (FSMFO)

Flame Scanner Not Sensing Igniter Spark (FSNSIS)

Igniter Timing (IT)

Main Flame Ignition Timing (MFIT)

Pre-Purge and Post-Purge Timing (PPT)

Low-Fire Proving Switch (LFPS)

Forced Draft Damper Wide-Open Pre-Purge Proving Switch(FDDWOPS)

Combustion Air Pressure Switch (CAPS) -Variable Speed Fan

Combustion Air Pressure Switch (CAPS) - Constant Speed Fan

Purge Airflow Proving Switch (PAPS)

Forced Draft Motor Interlock Switches (FDMIS)

Outlet Stack Damper Position Interlock Switch (OSDPI)

Furnace Pressure Interlock (FPI)

Low Pilot Fuel Gas Pressure Cutoff Switch (LPFGPCS)

Flue Gas Recirculation Damper Interlock (FGRDI)

Low Flue Gas Oxygen Level Interlock (LFGOLI)

Low Fuel Oil Pressure Cutoff Switch (LFOPCS)

High Fuel Oil Pressure Cutoff Switch (HFOPCS)

Low Atomizing Media Pressure Switch (LAMPS)

Low Atomizing Media Differential Pressure Switch (LAMDPS)

Low Atomizing Media Flow Switch (LAMFS)

Automatic Fuel Oil Shutoff Valves (AFOSV) - for Seat Leakage

Proof of Closure on Automatic Fuel Oil Shutoff Valves (POC-AFOSV)

Oil Burner Position Switch (OBPS)

Low Water Cutouts (LWCOHW and ALWCOHW)

Liquid Relief Valve (LRCHW)

High Water Temperature Switch (HWTS)

Flow Switch (FS)