**********
USACE / NAVFAC / AFCEC / NASA | UFGS-23 52 00 (April 2008)
Change 5 - 11/19
---
Preparing Activity: USACE | Superseding
UFGS-23 52 00.00 10 (January 2008)

**UNIFIED FACILITIES GUIDE SPECIFICATIONS**

**References are in agreement with UMRL dated July 2023**
**********

SECTION TABLE OF CONTENTS

DIVISION 23 - HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)

SECTION 23 52 00

HEATING BOILERS

**04/08, CHG 5: 11/19**

PART 1 GENERAL

1.1 REFERENCES
1.2 SUBMITTALS
1.3 QUALITY ASSURANCE
1.4 DELIVERY, STORAGE, AND HANDLING
1.5 EXTRA MATERIALS

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT
2.1.1 Standard Products
2.1.2 Asbestos Prohibition
2.1.3 Nameplates
2.1.4 Equipment Guards
2.2 BOILERS
2.2.1 Firetube Boiler
2.2.2 Watertube Boiler
2.2.3 Cast Iron Boiler
2.2.4 Condensing Boiler
2.2.5 Modular Configuration
2.2.6 Hot Water Heating Boilers
2.2.7 Steam Heating Boilers
2.3 FUEL BURNING EQUIPMENT
2.3.1 Burners
2.3.1.1 Gas and Combination Gas-Oil Fired Burners and Controls
2.3.1.2 Oil-Fired Burners and Controls
2.3.1.3 Steam or Air Atomizer
2.3.1.4 Mechanical pressure atomizer
2.3.2 Draft Fans
2.3.2.1 Draft Fan Control
2.3.2.2 Draft Fan Drives
2.3.3 Draft Damper
2.3.4 Ductwork

2.4 COMBUSTION CONTROL EQUIPMENT
2.4.1 Pneumatic Controls
2.4.1.1 Air Compressor Unit
2.4.1.2 Air Receiver
2.4.2 Electrical controls
2.4.3 Water Temperature Controller
2.4.4 Steam Pressure Controller
2.4.5 Boiler Plant Master Controller
2.4.6 Boiler Combustion Controls and Positioners
2.4.7 Combustion Safety Controls and Equipment
2.4.7.1 Low-water Cutoff
2.4.7.1.1 Feedwater Regulator with Low-Water Cutoff
2.4.7.1.2 Pump Controller with Low-Water Cutoff
2.4.7.1.3 Supplementary Low-Water Cutoff
2.4.7.2 Water Flow Interlock
2.5 PUMPS
2.5.1 Fuel Oil Pumping and Heating Sets
2.5.2 Hot Water and Boiler Circulating Pumps
2.5.3 Condensate Pumping Unit
2.5.3.1 Controls for Space Heating Steam Loads Only
2.5.3.2 Space Heating and Steam Loads or Distribution Lines
2.5.3.3 Rating and Testing
2.5.4 Vacuum Pumping Unit
2.6 COLD WATER CONNECTIONS
2.7 RADIATORS AND CONVECTORS
2.8 RADIANT FLOOR HEATING SYSTEMS
2.8.1 Tubing
2.8.2 Joints
2.8.3 Manifold
2.9 UNIT HEATERS
2.9.1 Propeller Fan Heaters
2.9.2 Centrifugal Fan Heaters
2.9.3 Heating Elements
2.9.4 Motors
2.9.5 Motor Switches
2.9.6 Controls
2.10 HEATING AND VENTILATING UNITS
2.11 AIR HANDLING UNITS
2.12 FITTINGS AND ACCESSORIES
2.12.1 Soot Blowers
2.12.1.1 Air Compressor Unit
2.12.1.2 Air Receiver
2.12.2 Continuous Emissions Monitoring
2.12.2.1 Gaseous Emission Monitors
2.12.2.2 Flue Gas Flow Monitor
2.12.2.3 Particulate Matter Monitor
2.12.2.4 Wiring
2.12.3 Tankless Water Heater
2.12.4 Conventional Breeching and Stacks
2.12.4.1 Breeching
2.12.4.2 Stacks
2.12.5 Direct Vents
2.12.5.1 Combustion Air Intake Vent
2.12.5.2 Exhaust Vent
2.12.6 Expansion Tank
2.12.7 Air Separator
2.12.8 Filters
2.12.9 Foundation (Setting) Materials
2.12.9.1 Firebrick

2.12.9.2 Tile
2.12.9.3 Insulating Brick
2.12.9.4 Refractory Mortar
2.12.9.5 Castable Refractories
2.12.10 Steel Sheets
2.12.10.1 Galvanized Steel
2.12.10.2 Uncoated Steel
2.12.11 Gaskets
2.12.12 Steel Pipe and Fittings
2.12.12.1 Steel Pipe
2.12.12.2 Steel Pipe Fittings
2.12.12.3 Steel Flanges
2.12.12.4 Welded Fittings
2.12.12.5 Cast-Iron Fittings
2.12.12.6 Malleable-Iron Fittings
2.12.12.7 Unions
2.12.12.8 Threads
2.12.12.9 Grooved Mechanical fittings
2.12.13 Copper Tubing and Fittings
2.12.13.1 Copper Tubing
2.12.13.2 Solder-Joint Pressure Fittings
2.12.13.3 Flared Fittings
2.12.13.4 Adapters
2.12.13.5 Threaded Fittings
2.12.13.6 Brazing Material
2.12.13.7 Brazing Flux
2.12.13.8 Solder Material
2.12.13.9 Solder Flux
2.12.13.10 Grooved Mechanical Fittings
2.12.14 Dielectric Waterways and Flanges
2.12.15 Flexible Pipe Connectors
2.12.16 Pipe Supports
2.12.17 Pipe Expansion
2.12.17.1 Expansion Loops
2.12.17.2 Expansion Joints
2.12.17.2.1 Bellows-Type joint
2.12.17.2.2 Flexible Ball Joint
2.12.17.2.3 Slip Type Expansion Joint
2.12.18 Valves
2.12.18.1 Gate Valves
2.12.18.2 Globe Valves
2.12.18.3 Check Valves
2.12.18.4 Angle Valves
2.12.18.5 Ball Valves
2.12.18.6 Plug Valves
2.12.18.7 Grooved End Valves
2.12.18.8 Balancing Valves
2.12.18.9 Automatic Flow Control Valves
2.12.18.10 Butterfly Valves
2.12.18.11 Drain valves
2.12.18.12 Safety Valves
2.12.19 Strainers
2.12.20 Pressure Gauges
2.12.21 Thermometers
2.12.22 Air Vents
2.12.22.1 Manual Air Vents
2.12.22.2 Automatic Air Vents
2.12.23 Steam Traps
2.12.23.1 Thermostatic Traps

2.12.23.2 Float-and-Thermostatic Traps
2.12.23.3 Inverted Bucket Traps
2.13 ELECTRICAL EQUIPMENT
2.13.1 Motor Ratings
2.13.2 Motor Controls
2.14 INSULATION
2.15 TOOLS
2.15.1 Breeching Cleaner
2.15.2 Tube Cleaner
2.15.3 Tube Brush
2.15.4 Wrenches
2.16 FUEL OIL STORAGE SYSTEM
2.17 BOILER WATER TREATMENT
2.17.1 MakeUp Water Analysis
2.17.2 Boiler Water Limits
2.17.3 Water Softening System
2.17.4 Chemical Feed Pumps
2.17.5 Tanks
2.17.6 Injection Assemblies
2.17.7 Water Meter
2.17.8 Water Treatment Control Panel
2.17.9 Sequence of Operation
2.17.10 Chemical Shot Feeder
2.17.11 Chemical Piping
2.17.12 Test Kits
2.17.13 Glycol Feed System
2.17.13.1 Supply Tank and Stand
2.17.13.2 Glycol Pump
2.17.13.3 Pressure Switch
2.17.13.4 Level Switch
2.17.13.5 Control Panel

PART 3 EXECUTION

3.1 EXAMINATION
3.2 ERECTION OF BOILER AND AUXILIARY EQUIPMENT
3.3 PIPING INSTALLATION
3.3.1 Hot Water Piping and Fittings
3.3.2 Vent Piping and Fittings
3.3.3 Gauge Piping
3.3.4 Steam Piping and Fittings
3.3.5 Condensate Return Pipe and Fittings
3.3.6 Joints
3.3.6.1 Threaded Joints
3.3.6.2 Welded Joints
3.3.6.3 Grooved Mechanical Joints
3.3.6.4 Flared and Brazed Copper Pipe and Tubing
3.3.6.5 Soldered Joints
3.3.6.6 Copper Tube Extracted Joint
3.3.7 Flanges and Unions
3.3.8 Branch Connections
3.3.8.1 Branch Connections for Hot Water Systems
3.3.8.2 Branch Connections for Steam Systems
3.3.9 Steam Connections to Equipment
3.3.10 Steam Risers
3.3.11 Air Vents for Steam Systems
3.3.12 Flared, Brazed, and Soldered Copper Pipe and Tubing
3.3.13 Copper Tube Extracted Joint
3.3.14 Supports

3.3.14.1 Seismic Requirements for Supports and Structural Bracing
3.3.14.2 Pipe Hangers, Inserts, and Supports
3.3.14.2.1 Types 5, 12, and 26
3.3.14.2.2 Type 3
3.3.14.2.3 Type 18
3.3.14.2.4 Type 19 and 23 C-Clamps
3.3.14.2.5 Type 20 Attachments
3.3.14.2.6 Type 24
3.3.14.2.7 Horizontal Pipe Supports
3.3.14.2.8 Vertical Pipe Support
3.3.14.2.9 Type 35 Guides
3.3.14.2.10 Horizontal Insulated Pipe
3.3.14.2.11 Piping in Trenches
3.3.14.2.12 Structural Steel Attachments
3.3.14.3 Multiple Pipe Runs
3.3.15 Anchors
3.3.16 Valves
3.3.17 Pipe Sleeves
3.3.17.1 Pipes Passing Through Waterproofing Membranes
3.3.17.2 Optional Modular Mechanical Sealing Assembly
3.3.17.3 Optional Counterflashing
3.3.17.4 Fire Seal
3.3.18 Balancing Valves
3.3.19 Thermometer Wells
3.3.20 Air Vents
3.3.21 Escutcheons
3.3.22 Drains
3.3.23 Strainer Blow-Down Piping
3.3.24 Direct Venting for Combustion Intake Air and Exhaust Air
3.4 GAS FUEL SYSTEM
3.5 FUEL OIL SYSTEM
3.5.1 Piping and Storage Tank
3.5.2 Fuel-Oil Storage Tank Heating-Coil Piping
3.5.3 Automatic Safety Shutoff Valve
3.5.4 Earthwork
3.6 RADIANT FLOOR HEATING SYSTEM
3.6.1 Concrete Slab construction
3.6.2 Wooden Floor Construction
3.6.3 Penetrations to Fire Rated Assemblies
3.7 COLOR CODE MARKING AND FIELD PAINTING
3.8 MANUFACTURER'S SERVICES
3.9 TEST OF BACKFLOW PREVENTION ASSEMBLIES
3.10 HEATING SYSTEM TESTS
3.10.1 Water Treatment Testing
3.10.2 Boiler/Piping Test
3.11 CLEANING
3.11.1 Boilers and Piping
3.11.2 Heating Units
3.12 FIELD TRAINING
3.13 FUEL SYSTEM TESTS
3.13.1 Fuel Oil System Test
3.13.2 Gas System Test

-- End of Section Table of Contents --

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|---|---|
| **USACE / NAVFAC / AFCEC / NASA** | **UFGS-23 52 00 (April 2008)** |
| | **Change 5 - 11/19** |
| | **----------** |
| **Preparing Activity: USACE** | **Superseding** |
| | **UFGS-23 52 00.00 10 (January 2008)** |

**UNIFIED FACILITIES GUIDE SPECIFICATIONS**

**References are in agreement with UMRL dated July 2023**
**********

SECTION 23 52 00

HEATING BOILERS
**04/08, CHG 5: 11/19**

**********
**NOTE: This guide specification covers the requirements for packaged hot water and steam boiler systems (oil, gas or combination oil/gas fired) of up to 6000 kW 20,000,000 Btuh output capacity. The hot water boiler systems operate at water temperatures below 120 degrees C 250 degrees F and water working pressures less than 1100 kPa 160 psi. The steam heating systems operate up to 100 kPa 15 psig.**

**Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.**

**Remove information and requirements not required in respective project, whether or not brackets are present.**

**Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).**
**********

PART 1 GENERAL

1.1 REFERENCES

**********
**NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.**

**Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.**

**References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.**

**********

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

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL, INC. (AMCA)

| | |
|---|---|
| AMCA 801 | (2001; R 2008) Industrial Process/Power Generation Fans: Specification Guidelines |

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

| | |
|---|---|
| ANSI Z21.13/CSA 4.9 | (2022) Gas-Fired Low Pressure Steam and Hot Water Boilers |

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

| | |
|---|---|
| ASHRAE 52.2 | (2012) Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size |

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

| | |
|---|---|
| ASME B1.20.1 | (2013; R 2018) Pipe Threads, General Purpose (Inch) |
| ASME B1.20.2M | (2006; R 2011) Pipe Threads, 60 Deg. General Purpose (Metric) |
| ASME B16.3 | (2021) Malleable Iron Threaded Fittings, Classes 150 and 300 |
| ASME B16.4 | (2021) Gray Iron Threaded Fittings; Classes 125 and 250 |
| ASME B16.5 | (2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard |
| ASME B16.9 | (2018) Factory-Made Wrought Buttwelding Fittings |
| ASME B16.11 | (2022) Forged Fittings, Socket-Welding and Threaded |
| ASME B16.15 | (2018) Cast Copper Alloy Threaded Fittings |

| | |
|---|---|
| | Classes 125 and 250 |
| ASME B16.18 | (2021) Cast Copper Alloy Solder Joint Pressure Fittings |
| ASME B16.20 | (2017) Metallic Gaskets for Pipe Flanges |
| ASME B16.22 | (2021) Wrought Copper and Copper Alloy Solder Joint Pressure Fittings |
| ASME B16.26 | (2018) Standard for Cast Copper Alloy Fittings for Flared Copper Tubes |
| ASME B16.34 | (2021) Valves - Flanged, Threaded and Welding End |
| ASME B16.39 | (2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300 |
| ASME B31.1 | (2022) Power Piping |
| ASME B31.5 | (2022) Refrigeration Piping and Heat Transfer Components |
| ASME B40.100 | (2022) Pressure Gauges and Gauge Attachments |
| ASME BPVC SEC IV | (2017) BPVC Section IV-Rules for Construction of Heating Boilers |
| ASME BPVC SEC IX | (2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications |
| ASME BPVC SEC VIII D1 | (2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1 |
| ASME CSD-1 | (2021) Control and Safety Devices for Automatically Fired Boilers |
| ASME PTC 10 | (1997; R 2014) Performance Test Code on Compressors and Exhausters |

AMERICAN WATER WORKS ASSOCIATION (AWWA)

| | |
|---|---|
| AWWA C606 | (2022) Grooved and Shouldered Joints |

AMERICAN WELDING SOCIETY (AWS)

| | |
|---|---|
| AWS A5.8/A5.8M | (2019) Specification for Filler Metals for Brazing and Braze Welding |
| AWS B2.2/B2.2M | (2016) Specification for Brazing Procedure and Performance Qualification |

ASTM INTERNATIONAL (ASTM)

| | |
|---|---|
| ASTM A53/A53M | (2022) Standard Specification for Pipe, |

| | |
|---|---|
| | Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless |
| ASTM A105/A105M | (2021) Standard Specification for Carbon Steel Forgings for Piping Applications |
| ASTM A167 | (2011) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip |
| ASTM A183 | (2014; R 2020) Standard Specification for Carbon Steel Track Bolts and Nuts |
| ASTM A193/A193M | (2023) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications |
| ASTM A234/A234M | (2023a) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service |
| ASTM A515/A515M | (2017; R2022) Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service |
| ASTM A516/A516M | (2017) Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service |
| ASTM A536 | (1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings |
| ASTM A653/A653M | (2023) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process |
| ASTM B32 | (2020) Standard Specification for Solder Metal |
| ASTM B62 | (2017) Standard Specification for Composition Bronze or Ounce Metal Castings |
| ASTM B75/B75M | (2020) Standard Specification for Seamless Copper Tube |
| ASTM B88 | (2022) Standard Specification for Seamless Copper Water Tube |
| ASTM B88M | (2020) Standard Specification for Seamless Copper Water Tube (Metric) |
| ASTM B813 | (2016) Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube |

| | |
|---|---|
| ASTM B828 | (2016) Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings |
| ASTM C27 | (1998; R 2022) Fireclay and High-Alumina Refractory Brick |
| ASTM C34 | (2017) Standard Specification for Structural Clay Loadbearing Wall Tile |
| ASTM C155 | (1997; R 2022) Standard Specification for Insulating Firebrick |
| ASTM C401 | (2012; R 2022) Alumina and Alumina-Silicate Castable Refractories |
| ASTM D596 | (2001; R 2018) Standard Guide for Reporting Results of Analysis of Water |
| ASTM D1784 | (2020) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds |
| ASTM D2000 | (2018) Standard Classification System for Rubber Products in Automotive Applications |
| ASTM F876 | (2023) Standard Specification for Crosslinked Polyethylene (PEX) Tubing |
| ASTM F1097 | (2017; R 2022) Standard Specification for Mortar, Refractory (High-Temperature, Air-Setting) |
| ASTM F1139 | (1988; R 2019) Steam Traps and Drains |

COMPRESSED AIR AND GAS INSTITUTE (CAGI)

| | |
|---|---|
| CAGI B19.1 | (2010) Safety Standard for Compressor Systems |

COPPER DEVELOPMENT ASSOCIATION (CDA)

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

EXPANSION JOINT MANUFACTURERS ASSOCIATION (EJMA)

| | |
|---|---|
| EJMA Stds | (2015) (10th Ed) EJMA Standards |

HYDRONICS INSTITUTE DIVISION OF AHRI (HYI)

| | |
|---|---|
| HI-004 | (1995) Radiant Floor Heating |
| HYI-005 | (2008) I=B=R Ratings for Boilers, Baseboard Radiation and Finned Tube (Commercial) |

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

| | |
|---|---|
| MSS SP-25 | (2018) Standard Marking System for Valves, Fittings, Flanges and Unions |
| MSS SP-58 | (2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation |
| MSS SP-70 | (2011) Gray Iron Gate Valves, Flanged and Threaded Ends |
| MSS SP-71 | (2018) Gray Iron Swing Check Valves, Flanged and Threaded Ends |
| MSS SP-72 | (2010a) Ball Valves with Flanged or Butt-Welding Ends for General Service |
| MSS SP-78 | (2011) Cast Iron Plug Valves, Flanged and Threaded Ends |
| MSS SP-80 | (2019) Bronze Gate, Globe, Angle and Check Valves |
| MSS SP-85 | (2011) Gray Iron Globe & Angle Valves Flanged and Threaded Ends |
| MSS SP-110 | (2010) Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends |

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

| | |
|---|---|
| NEMA 250 | (2020) Enclosures for Electrical Equipment (1000 Volts Maximum) |
| NEMA MG 1 | (2021) Motors and Generators |

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

| | |
|---|---|
| NFPA 31 | (2020) Standard for the Installation of Oil-Burning Equipment |
| NFPA 54 | (2021) National Fuel Gas Code |
| NFPA 70 | (2023) National Electrical Code |
| NFPA 85 | (2023) Boiler and Combustion Systems Hazards Code |
| NFPA 211 | (2019) Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances |

U.S. DEPARTMENT OF ENERGY (DOE)

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

UNDERWRITERS LABORATORIES (UL)

| | |
|---|---|
| UL 296 | (2017; Reprint Nov 2022) UL Standard for Safety Oil Burners |
| UL 726 | (1995; Reprint Oct 2013) Oil-Fired Boiler Assemblies |
| UL 795 | (2016; Reprint May 2022) UL Standard for Safety Commercial-Industrial Gas Heating Equipment |
| UL 1738 | (2020; Reprint Aug 2021) UL Standard for SafetyVenting Systems for Gas-Burning Appliances, Categories II, III and IV |
| UL FLAMMABLE & COMBUSTIBLE | (2012) Flammable and Combustible Liquids and Gases Equipment Directory |

1.2 SUBMITTALS

**********

**NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a “G” to an item, if the submittal is sufficiently important or complex in context of the project.**

**For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.**

**The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.**

**Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.**

**********

Government approval is required for submittals with a "G" or "S"

classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Detail Drawings

SD-03 Product Data

Materials and Equipment

[ Energy Star label for residential gas fired hot water boiler product; S

][ Energy Star label for residential oil fired hot water boiler product; S

] Spare Parts

Water Treatment System

Boiler Water Treatment

Heating System Tests

Fuel System Tests

Unit Heaters

Welding

Qualifications

Field Instructions

Tests

SD-06 Test Reports

Heating System Tests

Fuel System Tests

Water Treatment Testing

SD-07 Certificates

Bolts

Continuous Emissions Monitoring

SD-10 Operation and Maintenance Data

Operation and Maintenance Instructions; G[, [_____]]

Water Treatment System; G[, [_____]]

SD-11 Closeout Submittals

Indoor Air Quality During Construction; S

## 1.3 QUALITY ASSURANCE

**********
**NOTE: Where pipeline, structural, or other welding is required on the same project, tests will be required accordingly. Testing may be by the coupon method as prescribed in the welding code or by special radiographic methods. If the need exists for more stringent pipe welding requirements, delete the sentences in the first set of brackets.**
**********

Submit a copy of qualified welding procedures and a list of names and identification symbols of qualified welders and welding operators, at least 2 weeks prior to the start of welding operations. [Weld and braze boilers and piping in accordance with qualified procedures using performance-qualified welders and welding operators. Use procedures and welders that are qualified in accordance with ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by ASME B31.1. Notify the Contracting Officer 24 hours in advance of tests, and perform the tests at the work site if practical. The welder or welding operator must apply the personally assigned symbol near each weld made as a permanent record. Weld structural members in accordance with Section 05 05 23.16 STRUCTURAL WELDING.] [Welding and nondestructive testing procedures for piping are specified in Section 40 05 13.96 WELDING PROCESS PIPING.]

## 1.4 DELIVERY, STORAGE, AND HANDLING

Protect equipment delivered and placed in storage from the weather, humidity and temperature variations, dirt and dust, and other contaminants.

## 1.5 EXTRA MATERIALS

Submit spare parts data for each different item of material and equipment specified, after approval of the detail drawings and no later than 2 months prior to the date of beneficial occupancy. Submit Detail Drawings consisting of equipment layout including installation details and electrical connection diagrams; combustion and safety control diagrams; ductwork layout showing the location of supports and hangers, typical hanger details, gauge reinforcement, reinforcement spacing rigidity classification, and static pressure and seal classifications; and piping layout showing the location of guides and anchors, the load imposed on each support or anchor (not required for radiant floor tubing), and typical support details. Include on the drawings any information required to demonstrate that the system has been coordinated and will properly function as a unit and to show equipment relationship to other parts of the work, including clearances required for operation and maintenance. Include in the data a complete list of parts and supplies, with current unit prices and source of supply, and a list of the parts recommended by the manufacturer to be replaced after 1 and 3 years of service.

PART 2 PRODUCTS

**********

**NOTE: In order to comply with UFC 1-200-02, designs must achieve energy consumption levels that are at least 30 percent below the ASHRAE 90.1 baseline. In accordance with P.L. 109-58 (Energy Policy Act of 2005), Executive Order 13423, and Federal Acquisition Regulation (FAR) Section 23.203 energy consuming products and systems must meet or exceed the performance criteria for ENERGY STAR®-qualified products as long as these requirements are nonproprietary. The ENERGY STAR product requirements are available on the web at** www.energystar.gov/products**. Where ENERGY STAR products are not applicable, energy consuming products and systems must meet or exceed the requirements of ASHRAE 90.1.**

**ENERGY STAR Eligibility Criteria Version 3.0 requires that residential boilers of less than 90 kW 300,000 Btuh energy input supplying low pressure steam or hot water for space heating applications have a minimum AFUE of 90 percent for gas-fired type or 87 percent for oil-fired type. Boilers intended only for commercial applications and/or with an input rating of 90 kW 300,000 Btuh or higher are not eligible for Energy Star.**

**If a FEMP efficiency is not stated for a particular boiler capacity, this document includes boiler efficiency requirements in conformance with ASHRAE 90.1. ASHRAE 90.1 requires that low and medium pressure boilers used primarily in commercial space heating applications meet the following thermal (Et) or combustion (Ec) efficiencies:**

**Natural Gas-fired Hot Water rated at 88 - 732 kW 300,000 - 2,500,000 Btuh capacity, Et = 80 percent.**

**Natural Gas-fired Hot Water rated greater than 732 kW 2,500,000 Btuh capacity, Ec = 82 percent.**

**Natural Gas-fired Steam (excluding natural draft) rated at 90 kW 300,000 Btuh capacity and larger, Et = 79 percent.**
**Natural Gas-fired - Natural Draft Steam rated at 90 kW 300,000 Btuh capacity and larger, Et = 77 percent.**

**#2 Oil-fired Water rated at 88 - 732 kW 300,000 - 2,500,000 Btuh capacity, Et = 82 percent.**

**#2 Oil-fired Water rated greater than 732 kW 2,500,000 Btuh capacity, Ec = 84 percent.**

**#2 Oil-fired Steam rated greater than 90 kW 300,000 Btuh capacity and larger, Et = 81 percent.**

**Include all equipment efficiencies on the equipment**

**schedules on the drawings.**
**********

## 2.1 MATERIALS AND EQUIPMENT

### 2.1.1 Standard Products

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of the products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Provide equipment supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site. Submit manufacturer's catalog data included with the detail drawings for the following:

a. Radiant floor heating system including tubing, joints, and manifold for radiant floor heating systems.

b. Data showing model, size, options, etc., that are intended for consideration. Ensure data submitted is adequate to demonstrate compliance with contract requirements. Include manufacturer's written installation instructions and manufacturer's recommendations for operation and maintenance clearances for the following:

(1) Boilers
(2) Unit Heaters
(3) Fuel Burning Equipment
(4) Combustion Control Equipment
(5) Pumps
(6) Fittings and Accessories
(7) Fuel Oil Storage System
(8) Water Treatment System

### 2.1.2 Asbestos Prohibition

Asbestos and asbestos-containing products will not be allowed.

### 2.1.3 Nameplates

Secure a plate to each major component of equipment containing the manufacturer's name, address, type or style, model or serial number, and catalog number. Also, display an Energy Star label as applicable. Provide an approved ASME stamp for each pressure vessel.

### 2.1.4 Equipment Guards

Fully enclose or guard belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts exposed to personnel contact in accordance with OSHA requirements. Properly guard high temperature equipment and piping exposed to contact by personnel or where it creates a potential fire hazard or cover with insulation of a type specified. Provide catwalks, operating platforms, ladders, and guardrails where shown and construct in accordance with Section [08 31 00 ACCESS DOORS AND PANELS][05 51 33 METAL LADDERS].

## 2.2 BOILERS

**********
**NOTE: A selection will be made between hot water**

**and steam service. Also select between firetube, water tube, cast iron, and condensing type boilers. Condensing type boilers should only be considered for hot water service. Natural draft/atmospheric burners will not be used for any boiler exceeding 300 kW 1,000,000 Btuh output. Delete inapplicable references. A Life Cycle Cost Analysis should be performed to determine the appropriate type of boiler.**

**********

Provide each boiler with the output capacity in kilowatts (kW) British thermal units per hour (Btuh) as indicated when fired with the specified fuels. Furnish boiler complete with the [oil] [gas] [combination oil/gas] burning equipment, boiler fittings and trim, automatic controls, [[forced] [induced] draft fan,] [natural draft/atmospheric burner,] electrical wiring, insulation, piping connections, and protective jacket. Assemble boiler completely and test at the manufacturer's plant. Provide boiler auxiliaries including fans, motors, drives, and similar equipment with at least 10 percent excess capacity to allow for field variations in settings and to compensate for any unforeseen increases in pressure losses in appurtenant piping and ductwork. However, do not size the boiler safety devices for a 10 percent excess capacity. Design and install the boiler and its accessories to permit ready accessibility for operation, maintenance, and service. Design, construct, and equip boilers in accordance with ASME BPVC SEC IV. Each boiler must be of the [firetube] [watertube] [cast iron] [condensing] type and designed for [water] [steam] service as specified herein. Base boiler capacity on the ratings shown in HYI-005 or as certified by the American Boiler Manufacturers Association, or American Gas Association.

2.2.1 Firetube Boiler

Provide self-contained, multipass, packaged type boiler, complete with all accessories, mounted on a structural steel base. When the boilers are operating at maximum output, the heat input rates must not be greater than 21 Kw/square meter 6,700 Btuh per square ft of fireside heating surface.

2.2.2 Watertube Boiler

**********

**NOTE: Select between standard, finned, or bent/flexible tube boiler. If bent or flexible tube boilers are not selected, remove all references to bent or flexible tube boilers. Standard water tube boilers are steel tube boilers that have historically been used for most heating applications. Finned tube boilers are typically small boilers (residential type) that utilize a finned tube arrangement. Bent or flexible tube boilers are steel tube boilers with bent tubes that experience multiple water tube passes. Bent/Flexible tube boilers typically require less space than standard water tube boilers. The bent or flexible tubes are also easier to replace than the standard water tubes; however, the interior surface of the tubes cannot be cleaned mechanically; they can only be chemically cleaned. Bent or flexible tube boilers also have a higher ratio of heat output**

**to heating surface area.**
**********

Provide a [standard] [finned] [bent or flexible] type of water tube boiler. Provide a self-contained, packaged type boiler, complete with all accessories, mounted on a structural steel base. [The boiler heating surface area for bent or flexible tube boilers must be at least 0.03 square meters/kW 4 square feet/boiler horse power. [The heat input rate for finned tube steam boiler or hot water generator must not be greater than3.5 kW 12,000 Btuh based on internal heating area. ]Provide bent or flexible tube boilers with single or multiple downcomers for circulation without the need for exterior pumping. Design the tubes for bent or flexible tube boilers for replacement without requiring welding or rolling of tubes. Provide any special tools required for bent or flexible tube removal or installation with the boiler.]

2.2.3 Cast Iron Boiler

Provide rectangular, sectional type, self-contained, packaged type boiler, complete with accessories, mounted on a structural steel base. Use cast iron sections that are free of leaks under all operating conditions. Provide access to permit cleaning of internal tube surfaces.

2.2.4 Condensing Boiler

**********

**NOTE: Due to the sulfur content of fuel oil, condensing boilers should only be considered if natural gas is used.**

**The lower the return temperature of water entering the boiler the higher the resulting boiler efficiency. (See ASHRAE HVAC Equipment and Applications Handbook). The return water temperature should be at or below the dew point of the flue gas to result in the formation of condensate. This condition may not occur within a steam heating system. Therefore, condensing boilers should only be used for hot water service. In addition, the water distribution system and heating coils should be designed for higher temperature differentials.**

**Condensing boilers may be in the form of fire tube boilers with pulse combustion, copper fire tube boilers, or multiple heat exchanger boilers. The military specifications listed in the preceding paragraphs concerning fire tube and water tube boilers do not apply to condensing boilers.**
**********

Provide a self-contained packaged type boiler, complete with accessories, mounted on a structural steel base or a steel base which is integral to the boiler shell. Each boiler must conform to the commercial design used by the manufacturer and permit free thermal expansion without placing undue stress on any part of the boiler. Design each boiler which experiences the formation of condensate within the flue gas specifically for condensing application. Each boiler must withstand the corrosive effects of condensate for each part which may be in contact with the

condensate at all possible operating conditions. Provide each boiler with a separate air intake, exhaust, and condensate drain. Design each boiler to withstand the water temperature differentials anticipated at the required operating conditions without experiencing any damage due to thermal shock.

2.2.5 Modular Configuration

**********

**NOTE: A modular configuration is a series of small cast iron type and/or condensing type boilers. The smaller boilers are manifolded together to provide heating for larger loads. This arrangement may be economical when heating load variances are expected. Delete this paragraph if a modular configuration is not desired.**

**********

Provide [cast iron] [and] [condensing] type modular boilers with the capability of independent operation. Upon failure of any module, ensure the remaining modules are capable of operating at their designed capacity. Use size of the individual modules as indicated.

2.2.6 Hot Water Heating Boilers

**********

**NOTE: Hot water heating boilers will operate at pressures not over 1100 kPa 160 psi and at temperatures not above 120 degrees C 250 degrees F at or near the boiler outlet. If a pressure above 200 kPa 30 psi is selected, the boiler may be required to be manned 24 hours a day. Consult AR 420-49 for boiler attendance requirements. Fill in blank spaces to define operating conditions, under the listed subparagraphs which are not applicable to the design. Indicate the elevation of the project site and outdoor ambient air temperature range expected at the project site. Site conditions affect fan selection, boiler design, and stack design. Select appropriate boiler types. Allow adequate space around each boiler to permit accessibility for operation, maintenance, and service (including space for tube removal). A minimum clearance of 1200 mm 4 feet around the boiler will be required unless modular boilers are specified. Some modular boilers installations require little or no room between the individual boilers.**

**********

Provide hot water heating boiler capable of operating at the specified maximum continuous capacity without damage or deterioration to the boiler, its setting, firing equipment, or auxiliaries. The rated capacity is the capacity at which the boiler will operate continuously while maintaining at least the specified minimum efficiency. The boiler design conditions are as follows:

a. Boiler design pressure [200] [_____] kPa [30] [_____] psig.

b. Operating pressure at boiler outlet [_____] kPa psig.

c. Hot water temperature [70] [80] [_____] degrees C [160] [180] [_____] degrees F.

d. Temperature differential between boiler discharge and system return [_____] degrees C degrees F.

e. Water pressure drop [70] [_____] kPa [10] [_____] psig.

f. Outdoor ambient air temperature [_____] degrees C degrees F (max), [_____] degrees C degrees F (min).

g. Site elevation [_____] m feet.

h. Maximum continuous capacity [_____] kW Btuh.

i. Rated capacity [_____] kW Btuh.

j. Maximum exhaust stack temperature [_____] degrees C degrees F.

**********

**NOTE: Energy efficiency data for residential boilers provided in item "k" below is from Energy Star Program Requirements Product Specification for Boilers, Eligibility Criteria Version 3.0. Energy efficiency data for commercial boilers provided in item "k" below is from ASHRAE 90.1 Table 6.8.1F.**

**********

k.[ Residential gas fired hot water boilers with a capacity less than 90 kW 300,000 Btu must have an Annual Fuel Utilization Efficiency of at least 90 percent, and must be Energy Star Labeled. Provide proof of Energy Star label for residential gas fired hot water boiler product.][ Residential oil fired hot water boilers with a capacity less than 90 kW 300,000 Btu must have an Annual Fuel Utilization Efficiency of at least 87 percent, and must be Energy Star Labeled. Provide proof of Energy Star label for residential oil fired hot water boiler product.][ Hot water boilers with a capacity less than 90 kW 300,000 Btuh must have an Annual Fuel Utilization Efficiency of at least 80 percent.][ Gas fired boilers with a capacity of greater than or equal to 90 kW 300,000 Btuh and less than or equal to 733 kW 2,500,000 Btuh must have a thermal efficiency of at least 80 percent when fired at the maximum and minimum ratings allowed by the controls.][ Gas fired boilers with a capacity of greater than 733 kW 2,500,000 Btuh must have a combustion efficiency of at least 82 percent when fired at the maximum and minimum ratings allowed by the controls][ Oil fired boilers with a capacity of greater than or equal to 90 kW 300,000 Btuh and less than or equal to 733 kW 2,500,000 Btuh must have a thermal efficiency of at least 82 percent when fired at the maximum and minimum ratings allowed by the controls.][ Oil fired boilers with a capacity of greater than 733 kW 2,500,000 Btuh must have a combustion efficiency of at least 84 percent when fired at the maximum and minimum ratings allowed by the controls.]

**********

**NOTE: Minimum boiler efficiencies will either be**

**presented in this specification or on the design drawings. Delete boiler efficiencies in the specification if efficiencies are shown on the drawings. If the efficiencies are shown on the drawings, reference the applicable standard.**

**********

2.2.7 Steam Heating Boilers

**********

**NOTE: Steam boilers will operate at pressures below 100 kPa 15 psi. In case of installation of a small boiler where the omission of the water column is standard in some manufacturers, the water column requirement and other inapplicable words will be deleted. However, if the water column requirement is deleted from the specification, include a visible water column in the external piping arrangement to the boiler. The boiler feed water piping must contain a loop or trap. The bottom portion of the trap must be below the anticipated water level within the boiler. All piping arrangements will be shown on the drawings. Delete those subparagraphs which are not applicable to the design. Indicate the elevation of the project site and the outdoor ambient air temperature range expected at the project site. Site conditions affect fan selection, boiler design, and stack design. Select the feed water temperature to avoid thermal shock. Typical ranges are between 10 degrees C 20 degrees F and 20 degrees C 40 degrees F below the boiler outlet temperature. The boiler manufacturer should be consulted for proper selection. Select appropriate boiler types. Allow adequate space around each boiler to permit accessibility for operation, maintenance, and service (including space for tube removal). A minimum of 1200 mm 4 feet around the boiler will be required.**

**********

Provide boiler with a water column with gauge glass and fittings including water column and gauge glass drain valves of the straight through type. Provide steam heating boiler that is capable of operating at the specified maximum continuous capacity without damage or deterioration to the boiler, its setting, firing equipment, or auxiliaries. The rated capacity is the capacity at which the boiler will operate continuously while maintaining at least the specified minimum efficiency. Design conditions are as follows:

a. Boiler design pressure 200 kPa 30 psig.

b. Operating pressure at boiler outlet [_____] kPa psig.

c. Steam temperature 120 degrees C 250 degrees F.

d. Feedwater temperature [_____] degrees C degrees F.

e. Outdoor ambient air temperature [_____] degrees C degrees F (max), [_____] degrees C degrees F (min).

f. Site elevation [_____] m feet.

g. Maximum continuous capacity [_____] kg pounds of steam per hour.

h. Rated capacity [_____] kg pounds of steam per hour.

i. Maximum exhaust stack temperature [_____] degrees C degrees F.

**********

**NOTE: Energy efficiency data for commercial boilers provided in item "j" below is from ASHRAE 90.1 Table 6.8.1F.**

**********

j. [Gas fired boilers with a capacity less than 90 kW 300,000 Btuh must have an Annual Fuel Utilization Efficiency of at least 75 percent.][ Oil fired boilers with a capacity less than 90 kW 300,000 Btuh must have an Annual Fuel Utilization Efficiency of at least 80 percent.][ Gas fired boilers (all, except natural draft) with a capacity of greater than or equal to 90 kW 300,000 Btuh must have a thermal efficiency of at least 79 percent.][ Gas fired natural draft boilers with a capacity greater than or equal to 733 90 kW 300,000 Btuh must have a thermal efficiency of at least 77 percent.][ Oil fired boilers with a capacity greater than or equal to 90 kW 300,000 Btuh must have a thermal efficiency of at least 81 percent when fired at the maximum and minimum ratings allowed by the controls.]

**********

**NOTE: Minimum boiler efficiencies will either be presented in this specification or on the design drawings. Delete boiler efficiencies in the speciication if efficiencies aare shown on the drawing. If the efficiencies are shown on the drawings, reference the applicable standard.**

**********

## 2.3 FUEL BURNING EQUIPMENT

**********

**NOTE: Include all the required data for proper design of the boiler. Delete all references to fuels which will not be used. When firing fuel oil, include nitrogen and sulfur content of fuel for emission requirements.**

**Review the Clean Air Act Amendment of 1990 (CAAA) and other applicable Federal, state, and local regulations early in the design phase to determine the appropriate emission limitations and monitoring requirements.**

**The CAAA does not require the application of low NOx burner (LNB) technology for boilers within the size range of this specification. The CAAA limits SO2 emissions for fuel oil fired boilers over 10.55 gJ 10,000,000 Btu to 215 kg/nJ 0.5 lb per million Btu**

**input or to firing oil with less than 0.5 weight percent sulfur. However, state implementation plans may place limits on NOx and particulates and more stringent requirements on SO2.**

**Many options are available to reduce NOx emissions. The nitrogen and sulfur content of fuel oil should be specified in the fuel purchase contract. Restrictions on the nitrogen content will limit fuel flexibility. A careful analysis of proposed NOx reduction technologies must be performed to account for any required changes to auxiliary equipment and to identify future increase in O&M costs. Important questions that should be answered and be a part of the evaluation include the performance of NOx reduction over the entire load range, performance during backup fuel firing, and performance over the lifetime of the unit.**

**The majority of NOx control techniques can be defined as combustion modifications. The goals of combustion modification include redistribution of air and fuel to slow mixing, reduction of O2 in NOx formation zones, and reduction of the amount of fuel burned at peak flame temperatures.**

**Combustion modifications primarily deal with the control of fuel and air. Vertical staging includes overfire air (OFA) ports above the main combustion zone. Horizontal staging use registers or other devices to introduce air at different points along the flame. Fuel staging establishes a fuel rich zone above an air lean main combustion zone. Burner Out of Service (BOOS) techniques direct fuel to lower burner levels, while operating upper burners with air only. Flue Gas Recirculation (FGR) reduces O2 available to react with nitrogen and cools the flame. In addition to low NOx burners (LNB), OFA and BOOS other combustion modification techniques include fuel biasing, low excess air (LEA) and fuel reburning. Oil fired burners have successfully used advanced oil atomizers to reduce NOx without increasing opacity. Oil/water emulsion is a technique to reduce NOx on smaller industrial boilers.**

**Consideration will be given to the unique installation and space requirements of various NOx reduction systems. LNB may or may not require pressure port modifications. FGR involves routing large ductwork. OFA is very effective and involves modification to pressure parts. Fuel staging requires pressure port modifications for reburn fuel injection and/or OFA ports.**

**********

Design boiler to burn [gas] [oil] [combination gas and oil]. Each boiler must comply with Federal, state, and local emission regulations. As a minimum, meet the following emission requirements:

NOx - [[_____] kg/joule lb/million Btu input] [parts per million (ppm) corrected to 3 percent Oxygen by volume].

SO2 - [[_____] kg/joule lb/million Btu input] [parts per million (ppm) corrected to 3 percent Oxygen by volume].

Particulate - [[_____] kg/joule lb/million Btu input] [parts per million (ppm) corrected to 3 percent Oxygen by volume].

2.3.1 Burners

**********

**NOTE: If No. 4, 5, or 6 oil will be one of the fuels, requirements for burners and accessories for these heavy oils will be inserted in the project specification.**

**********

2.3.1.1 Gas and Combination Gas-Oil Fired Burners and Controls

Burners must be UL approved [mechanical draft burners with all air necessary for combustion supplied by a blower where the operation is coordinated with the burner] [natural draft/atmospheric burners]. Provide burner complete with fuel supply system in conformance with the following safety codes or standards:

a. Provide gas-fired units with inputs greater than 0.117 MW 400,000 Btuh per combustion chamber conforming to UL 795. [Provid gas fired units less than 3.66 MW 12,500,000 Btuh input conforming to ANSI Z21.13/CSA 4.9.] [Provide single and multiple burner gas-fired units greater than or equal to 3.66 MW 12,500,000 Btuh input conforming to NFPA 85.]

b. Provide combination gas and oil-fired units conforming to UL 296. [Provide combination gas and oil-fired units less than 3.66 MW 12,500,000 Btuh input conforming to ASME CSD-1.] [Provide single and multiple burner combination gas and oil-fired units equal to or greater than 3.66 MW 12,500,000 Btuh input conforming to NFPA 85.]

2.3.1.2 Oil-Fired Burners and Controls

Oil-fired burners and controls for oil-fired units firing No. [_____] oil must be atomizing, forced-draft type in conformance with UL 726. [Provide oil-fired units less than 3.66 MW 12,500,000 Btuh input conforming to ASME CSD-1.] [Provide oil-fired units greater than or equal to 3.66 MW 12,500,000 Btuh input conforming to NFPA 85.]

2.3.1.3 Steam or Air Atomizer

**********

**NOTE: Delete this paragraph if steam or air atomization is not used.**

**********

Provide [steam] [or] [air] atomizer of the inside mix type utilizing [steam] [or] [air] mixing with the oil inside the nozzle. No moving parts are required within the atomizer assembly. Provide unit that is capable of completely atomizing the oil through a minimum capacity range of 4 to 1

without changing nozzles or sprayer plates and when supplied with [steam] [or] [air] at a maximum pressure of [100] [_____] kPa [15] [_____] psig. Provide unit with adjustable capacity. Furnish unit with a blowout valve so that [steam] [or] [air] may be blown through the oil passages to clear them of any accumulation. Mount a diffuser designed to stabilize the flame near the furnace end of the atomizer in such a position that oil will not strike it.

2.3.1.4 Mechanical pressure atomizer

**********
**NOTE: If mechanical pressure atomization is not used delete this paragraph.**
**********

Operate mechanical pressure atomizer solely by the use of oil pressure and have no moving parts within the atomizer. Unit must be capable of completely atomizing the oil through a minimum capacity range of 4 to 1 without changing nozzles or sprayer plates and when furnished with oil at a constant pressure of [_____]. Supply a constant volume of oil to the atomizer. Obtain variable capacity by adjusting control valve. Mount a diffuser provided to stabilize the flame near the furnace end of the atomizer, but in such a position that oil will not strike it.

2.3.2 Draft Fans

**********
**NOTE: If natural draft/atmospheric burners are utilized, all draft fan paragraphs will be deleted. Select between forced draft and induced draft fan or a combination of both. In most applications, a forced draft fan will be adequate. Fan bearings on induced draft fans must have adequate means to prevent overheating and provision for lubrication. Choice of type of cooling will depend on availability of water for the particular site. Water-cooled bearings are generally used for induced draft fans but air-cooled, sealed-type bearings are available; however, their use must be approved by the fan manufacturer for the application if specified. Forced draft fans are typically air cooled.**
**********

Furnish fans conforming to AMCA 801 [forced-draft] [and] [induced-draft] as an integral part of boiler design. Provide centrifugal fans with [backward-curved blades] [radial-tip blades] or axial flow type. Size each fan for output volume and static pressure rating sufficient for pressure losses, excess air requirements at the burner, leakages, temperature, and elevation corrections for worst ambient conditions, all at full combustion to meet net-rated output at normal firing conditions, plus an overall excess air volume of 10 percent against a 20 percent static overpressure. Do not exceed noise levels of 85 decibels for fans in any octave band at a 0.914 m 3 foot station. [Air cool draft fan bearings.] [Design induced-draft fans for handling hot flue gas at the maximum outlet temperature in the boiler. Provide induced draft fan housings with drain holes to accommodate the drainage of condensation. [Air-cool] [Water-cool] induced draft fan bearings. Provide induced draft fan scroll sheets and rotor blades with protective liners.]

2.3.2.1 Draft Fan Control

[Provide forced-draft centrifugal fans with inlet vane controls or variable speed control where indicated. Provide inlet vanes suitable for use with combustion control equipment.] [Provide induced-draft centrifugal fans with outlet dampers and variable speed control.] [Provide induced-draft fans with inlet vane controls.] Provide axial propeller fans with variable propeller pitch control.

2.3.2.2 Draft Fan Drives

**********
**NOTE: Where motor starters for mechanical equipment are provided in motor control centers, delete the description of motor starters.**
**********

Drive fans by electric motors. Electric motor must be [drip proof] [totally enclosed nonventilated] [totally enclosed fan cooled] [totally enclosed fan-cooled, suitable for installation in a Class II, Division 1, Group F, hazardous location conforming to NFPA 70]. [Motor starter must be [magnetic across-the-line] [reduced voltage start] type with [general purpose] [weather-resistant] [watertight] [dust-tight] [explosion-proof] enclosure and furnished with four auxiliary interlock contacts.]

2.3.3 Draft Damper

**********
**NOTE: Select between manual and automatic dampers. Normally, manual dampers are adequate for single boilers less than 600 kW 2,000,000 Btuh capacity. Select automatic dampers for modular boilers.**
**********

Provide boilers with [manual] [automatic] dampers, draft hoods, or barometric dampers as recommended by the boiler manufacturer to maintain proper draft in the boiler. Provide draft damper in a convenient and accessible location in the flue gas outlet from the boiler. Arrange automatic damper for automatic operation by means of a [damper regulator] [furnace draft regulator] [damper motor].

2.3.4 Ductwork

**********
**NOTE: In colder climates, tempering of combustion air may be required. Add an appropriate paragraph for tempering combustion air, if required. Delete this paragraph, if a plenum chamber is not needed.**
**********

Design air ducts connecting the forced-draft fan units with the plenum chamber to convey air with a minimum of pressure loss due to friction. Provide ductwork consisting of galvanized sheet metal conforming to ASTM A653/A653M. Ducts must be straight and smooth on the inside with laps made in direction of air flow. Ducts must have cross-break with enough center height to assure rigidity in the duct section, angle iron braced, and completely free of vibration. Provide access and inspection doors as indicated and required, with a minimum of one in each section

between dampers or items of equipment. Construct ducts with long radius elbows having a centerline radius 1-1/2 times the duct width, or where the space does not permit the use of long radius elbows, short radius or square elbows with factory-fabricated turning vanes may be used. Duct joints must be substantially airtight and have adequate strength for the service, with 38 x 38 x 3 mm 1-1/2 x 1-1/2 x 1/8 inch angles used where required for strength or rigidity. Provide duct wall thickness of 16 gauge (1.5 mm0.0598 inch) for ducts 1500 mm 60 inches or less and 12 gauge (2.66 mm0.1046 inch) for ducts larger than 1500 mm 60 inches in maximum dimension. Additional ductwork must be in accordance with Section 23 30 00 HVAC AIR DISTRIBUTION.

## 2.4 COMBUSTION CONTROL EQUIPMENT

**********

**NOTE: If steam boilers are not utilized, delete all references to steam pressure controllers. If hot water boilers are not utilized, delete all references to water temperature controllers.**

**Controls for facilities with operating Energy Monitoring and Control Systems (EMCS) will be specified to be compatible with existing EMCS controls. Delete reference to multiple boilers if a single boiler is used.**

**Delete "pneumatic controls" for new systems. Use only pneumatic controls for existing pneumatic controls systems that require new parts be purchased.**

**********

Provide combustion control equipment as a system by a single manufacturer. Field install automatic combustion control system in accordance with the manufacturer's recommendations and under the direct supervision of a representative of the control manufacturer. [Control the boiler water temperature by a water temperature controller.] [Control the boiler pressure by a steam pressure controller.] Operate the equipment [electronically] [either electrically or pneumatically as applicable]. On multiple boiler installations, provide each boiler unit with a completely independent system of controls responding to the load and to a plant master controller. If recording instruments are provided, furnish a 1 year supply of ink and 400 blank charts for each recorder.

### 2.4.1 Pneumatic Controls

If pneumatic operation is provided, provide a regenerant desiccant air dryer unit. Shut down boiler on loss of control air pressure. Provide pneumatic control systems conforming to CAGI B19.1. Install air filter regulator sets at each control valve and transmitter in the system. Provide dual type master air filter regulator set where one side can be cleaned and repaired while the other is operating. Protect exterior control air piping and devices from freezing.

#### 2.4.1.1 Air Compressor Unit

Provide electric-motor driven, polytetrafluoroethylene or carbon ring type automatic air compressor unit. Size the compressor unit to run no more than 60 percent of the time when all controls are in service. Provide air compressor unit complete with necessary accessories including automatic

pressure control equipment, relief valves, check valves, air filters, moisture traps, and a receiver with ample capacity for emergency operation of the controls for 15 minutes after compressor shutdown. Do not exceed compressor speed of 900 rpm. Do not exceed motor speed of 1750 rpm. Provide compressor air intake with a low drop type air suction filter/silencer suitable for outdoor installation.

2.4.1.2 Air Receiver

**********

**NOTE: The condensate drain line will be located in such a manner as to prevent freezing.**

**********

Construct the air receiver in accordance with ASME BPVC SEC VIII D1for unfired pressure vessels for 1379 kPa 200 psi working pressure, and equipd with inlet and outlet connections, valved drain connection, minimum 150 mm 6 inch dial pressure gauge, pop safety valves, and regulator connections.

2.4.2 Electrical controls

Provide electrical control devices rated at [120] [24] volts and connect as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.4.3 Water Temperature Controller

**********

**NOTE: If hot water boilers are not utilized, the following paragraph will be deleted. Consideration will be given to the utilization of outside air reset controls. Outside air reset control is typically used for boilers whose primary loads are due to space heating applications. Information on outdoor air reset controls for space heating application is located in Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC and UFC 3-410-02 or inactive UFC 3-540-02N (** http://www.wbdg.org/ccb/DOD/UFC/INACTIVE/ufc_3_540_02n.pdf **). Consideration will be given to the use of control based on return water temperature rather than supply water temperature.**

**********

Provide controller made of sturdy construction and protect against dust and dampness. Insert the thermostatic element in a separable socket installed [in the upper part of the boiler near the water outlet] [in the boiler return piping]. [Operate fixed position (on-off) and three position (high-low-off) controller on a 5.56 degree C 10 degree F differential over an adjustable temperature range of approximately 60 to 104.4 degrees C 140 to 220 degrees F.] [Provide modulating controllers to control the fuel burning equipment to maintain set boiler water temperature within 2 percent.] [Furnish controller with necessary equipment to automatically adjust the setting to suit the outside weather conditions. Operate the outside air reset controller in such a manner that the operating temperatures required by the boiler manufacturer are not compromised.]

2.4.4 Steam Pressure Controller

**********

**NOTE: If steam boilers are not utilized the following paragraph will be deleted.**

**********

Provide controller made of sturdy construction and protect against dust and dampness. Ensure sensing elements of the steam controller are in direct contact with the steam. [Operate fixed position (on-off) and three position (high-low-off) type controllers on a 6.9 kPa 1 pound differential over a pressure range of 0 to 103.4 kPa 0 to 15 psig.] [Modulating controllers must automatically maintain, within 2 percent, the desired steam pressure by regulating the burner.]

2.4.5 Boiler Plant Master Controller

**********

**NOTE: If only one boiler is utilized, the following paragraph will be deleted. A master controller will be provided for applications involving multiple boilers and for boilers arranged in a modular configuration.**

**********

Furnish a boiler plant master controller, sensitive to a [temperature transmitter in the return water header for the boiler] [steam pressure transmitter in the boiler steam discharge header] to provide anticipatory signals to all boiler controllers. Boiler controllers must react to anticipatory signals from the plant master controller as necessary in response to the boiler [temperature] [pressure] indication to maintain the preset [temperature] [pressure]. Provide an automatic-manual switch to allow the sequence of boiler loading to be varied to distribute equal firing time on all boilers in the plant. The plant master controller must load the boilers one at a time as the plant load increases.

2.4.6 Boiler Combustion Controls and Positioners

**********

**NOTE: A pilot is required for all oil fired boilers over 875 kW 3,000,000 Btuh. However, a pilot is recommended for all fired boilers.**

**Select between fixed rate (on-off), three position (high-low-off), and modulating controls. Combustion controls will be fixed-rate, on-off for gross outputs up to 200 kW 700,000 Btuh; high-low-off or fixed-rate on-off, depending on anticipated load profile, for gross output from 200 to 600 kW 700,000 to 2,000,000 Btuh; high-low-off or modulating, depending on anticipated load profile, for gross output from 600 to 1200 kW 2,000,000 to 4,000,000 Btuh; modulating for gross outputs above 1200 kW 4,000,000 Btuh. Modular boilers will be fixed-rate on-off for each module. Delete inappropriate paragraphs.**

**********

a. Provide [gas] [combination gas-oil fired] boiler units with [fixed

rate (on-off)] [three position (high-low-off)] [modulating] combustion controls with gas pilot or spark ignition. Provide modulating controls with a means for manually controlling the firing rate.

b. Provide oil fired boiler units with [on-off] [high-low-off] [modulating] combustion controls with [direct electric spark ignition system] [spark ignited [No. 2 oil] [natural gas] [liquified petroleum gas] pilot]. Provide modulating controls with a means for manually controlling the firing rate.

c. Accomplish modulating control function positioning type controls. Control air flow ratio and fuel control valve relative positions of operative levers on a jackshaft responding to a [water temperature controller] [steam pressure controller]. Provide positioning type combustion control equipment including draft controls with synchronized fuel feed and combustion air supply controls that maintain the proper air/fuel ratio. Maintain the desired furnace draft within 0.25 mm 0.01 inch of water column.

d. [Fixed rate on-off] [High-low-off] controls for boilers with capacities up to 600 kW 2,000,000 Btuh must use a [water temperature controller in a temperature well in direct contact with the water] [steam pressure controller in direct contact with the steam].

2.4.7 Combustion Safety Controls and Equipment

**********

**NOTE: Provide feed water regulator with low-water cutoff on close coupled boilers (i.e. short supply and return lines with low pick-up losses) under 1200 kW 4,000,000 Btuh gross output with no process loads. Provide pump controller with low-water cutoff for all other boilers. Low-water cutoff will require a manual reset unless a supplementary low-water cutoff is provided. A supplementary low-water cutoff is required for boilers utilizing a pumped condensate return system. State and local codes may also require supplementary low-water cutoffs. When a supplementary low-water cutoff is provided, it will require manual reset and the initial low-water cutoff will not require manual reset.**

**Include the manually operated shutoff switch in the controls drawings, set point schedules and plans.**

**********

Provide combustion safety controls and equipment that are UL listed, microprocessor-based distributed process controller. Include mounting hardware, wiring and cables, and associated equipment. Mount completely wired, programmed, debugged controller, and test to perform all of its functions. Process the signals for complete control and monitoring of the boiler. This includes maintaining boiler status, starting and stopping all control functions, sequencing control functions and signaling alarm conditions. Document the program and include cross references in description of coils and contacts. Provide microprecessor to perform self diagnostics and contain a message center to provide operator with status and failure mode information. Mount controllers for each boiler on a separate, free standing panel adjacent to the boiler or for packaged

boilers on the boiler supporting structure. Provide control systems and safety devices for automatically fired boilers conforming to ASME CSD-1. Provide electrical combustion and safety controls rated at 120 volts, single phase, 60 Hz and connect as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Provide a 100 mm 4 inch diameter alarm bell and locate where indicated or directed. The alarm bell must ring when the boiler is shut down by any safety control or interlock. Provide indicating lights on the control panel. Use a red light to indicate flame failure, and a green light to indicate that the main fuel valve is open. The following shutdown conditions require a manual reset before the boiler can automatically recycle:

a. Flame failure.

b. Failure to establish pilot flame.

c. Failure to establish main flame.

d. [Low-water] [supplementary low-water] cutoff.

e. [High temperature cutoff] [High pressure cutoff].

2.4.7.1 Low-water Cutoff

**********

**NOTE: If state or local codes or regulations require a second cutoff, a separate supplementary low-water cutoff of the float type or electrode type may be provided. Delete supplementary low-water cutoff, if second cutoff is not required. Delete feedwater regulator and pump controller for water heating systems.**

**********

Provide float actuated switch or electrically actuated probe type low-water cutoff. Provide float chamber with a blow-down connection. Cutoff must cause a safety shutdown and sound an alarm when the boiler water level drops below a safe minimum level. A safety shutdown due to low water must require manual reset before operation can be resumed and prevent recycling of the burner. The cutoff must be in strict accordance to ASME CSD-1.

2.4.7.1.1 Feedwater Regulator with Low-Water Cutoff

Provide regulator of an approved design sized for the application. Provide a regulator for each boiler. Arrange the feeder so that water will be fed to the boiler automatically when the water level in the boiler drops below a preset point and will actuate the alarm bell when the water level reaches the low danger point. Arrange the boiler feeder so that the burner and forced-draft fan will stop whenever the water level drops below a preset danger point. Construct the boiler feeder so that the feedwater valve and seat are isolated from the float chamber to prevent overheating of the feed water and precipitation of scale on either the valve or seat. Construct each float mechanism, valve, and seat of an approved, durable, corrosion-resistant steel alloy. Provide removable and renewable valve seats. Equip regulator with a large, self-cleaning strainer. Use gate or other straight-through type drain valve on the regulator.

2.4.7.1.2 Pump Controller with Low-Water Cutoff

Provide controller of a design approved by the boiler manufacturer. Provide a pump controller for each boiler which is used for space heating and process steam loads or long distribution lines. Control the operation of the burner, forced-draft fan, and pump. Provide pump controller and low-water cutoff with a float-operated mercury switch arranged to start and stop the pump at preset boiler water levels. If the water level in the boiler reaches the low danger point, provide a second mercury switch to shut down the burner and actuate the alarm bell.

2.4.7.1.3 Supplementary Low-Water Cutoff

Provide supplementary low-water cutoff of the [electrically operated probe type] [float activated type] in addition to the low-water cutoff required above on each boiler. Mount supplementary low-water cutoff directly in the boiler shell and set below the low-water cutoff required above.

2.4.7.2 Water Flow Interlock

**********
**NOTE: Delete this paragraph if a hot water boiler is not utilized.**
**********

Provide hot water boiler limit controls to include protection for low boiler water flow and high boiler water temperature. Interlock the limit controls with the combustion control system to effect boiler alarm and shutdown. Do not allow boiler startup unless hot water flow is proven.

2.5 PUMPS

2.5.1 Fuel Oil Pumping and Heating Sets

**********
**NOTE: This paragraph may not be needed if the fuel does not require heating. This paragraph should be coordinated with Section 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS and any burner mounted pump. Select type I: simplex unit or type II duplex unit. Indicate the design requirements of filter/basket strainer located ahead of electric oil heater in order to match characteristics of fuel oil to be utilized. Select single filter/basket strainer for boilers below 60 kW 200,000 Btuh.**
**********

Provide [simplex] [duplex] and UL approved integrated, shop-fabricated oil pumping and heating set. Provide two positive displacement oil meters. Locate one meter on the fuel supply line. Locate the other meter on the fuel return line. Include an electric oil heater of adequate capacity to heat the specified fuel oil to ignition temperature at low boiler load until enough [hot water] [steam] is generated to operate the heat exchanger in each set. Control the electric heater by magnetic starter with a manually-operated On-Off switch in series with a thermostatic control. When oil temperature is raised to proper level and maintained by the [hot water] [steam] heater, disconnect the electric heater automatically by the thermostatic control. Provide electric-motor-driven fuel pumps. Each pump must have a capacity of no less than [_____] L/s gpm

at a discharge pressure of [_____] kPa psig with a suction lift of 3.74 kPa 15 feet. Install a [duplex] [single] filter/basket strainer system ahead of the electric oil heater and final discharge filter/strainer system.

2.5.2 Hot Water and Boiler Circulating Pumps

**********

**NOTE: Boiler and hot water circulating pumps must be selected at the most efficient point of the pump curve which will generally lie on the sloped portion of the curve.**

**If separate pumps are not needed to provide water flow to the boilers, delete the requirement for boiler circulating pumps. The flow switch or pressure switch will only be needed for the pump which provides flow through the boiler. Pipe supported pumps are typically available up to 1.5 kw 2HP. Closed-coupled pumps are typically available up to 3.7 kw 5HP.**

**********

Provide circulating pumps for hot water that are electrically driven single-stage centrifugal type and have a capacity no less than indicated. [Support boiler circulating pumps [on a concrete foundation with a cast iron or structural steel base] [or] [by the piping on which installed] and must be [closed-coupled shaft] [or] [flexible-coupled shaft]. The boiler circulating pumps must be [horizontal split case] [vertical split case] type]. [Support hot water circulating pumps [on a concrete foundation with a cast iron or structural steel base] [or] [by the piping on which installed] and with a [closed-coupled shaft] [or] [flexible-coupled shaft]. The hot water circulating pumps must be [horizontal split case] [vertical split case] type]. Construct pump shaft of corrosion-resistant alloy steel, sleeve bearings and glands of bronze designed to accommodate a mechanical seal, and the housing of close-grained cast iron. Use pump seals capable of withstanding 115 degrees C 240 degrees F temperature without external cooling. Provide motor with sufficient power for the service required, of a type approved by the manufacturer of the pump, suitable for the available electric service, and conforming to the requirements of paragraph ELECTRICAL EQUIPMENT. Provide each pump suction and discharge connection with a pressure gauge as specified. Provide the [boiler] [hot water] circulating pump discharge heater with a [flow switch] [pressure switch]. [Use a self-contained swinging vane type flow switch unit to indicate fluid flow.] [Use a self-contained snap action type pressure switch unit to indicate fluid pressure.] Provide switch that is a SPDT with 120-volt, 15-ampere rating.

2.5.3 Condensate Pumping Unit

**********

**NOTE: If steam is utilized, only one type of condensate return unit will be required; delete either the condensate pumping unit or the vacuum pumping unit. Delete this paragraph if hot water is utilized.**

**********

Each pump must have a capacity no less than that indicated when

discharging against the specified pressure. The minimum capacity of the tank is as indicated. The condensate pumping unit must be the [single] [duplex] [horizontal shaft] [vertical shaft] type as indicated. Provide unit consisting of [one pump] [two pumps] with electric motor drive, and a single receiver, all mounted on a suitable cast-iron or steel base. The motor may be mounted on the top of the receiving tank. Provide centrifugal or turbine type pump, bronze-fitted throughout, with impellers of bronze or other approved corrosion-resisting metal. Ensure pump is free from air binding when handling condensate of temperatures up to 93 degrees C 200 degrees F. Connect pump directly to suitable drip-proof enclosed motors. Receiver must be cast iron or not less than 4.75 mm 3/16 inch thick black iron or steel and provide with all the necessary reinforced threaded openings, including condensate return, vent, overflow, and pump suction connections. Provide inlet strainer either integral in the tank or separate in the inlet line to the tank. Provide galvanized steel vent pipe, and galvanized malleable iron fittings. Extend vent pipe through the roof and properly flash. The pump, motor, and receiving tank may be mounted on a single base with the receiver piped to the pump suctions. Provide a gate valve and check valve in the discharge connection from each pump and provide a strainer and gate valve in the suction line to each pump except where pumps are directly mounted on top of the receiver.

2.5.3.1 Controls for Space Heating Steam Loads Only

**********

**NOTE: For loads where space heating is only part of the steam load, delete this paragraph.**

**********

Install an enclosed float switch complete with float mechanisms in the head of the receiver. Control each condensate pump by a float switch which automatically starts the motor when the water in the receiving tank reaches the high level and stops the motor when the water reaches the low level. Provide motors with magnetic across-the-line starters equipped with general-purpose enclosures and three-position, "Manual-Off-Automatic" selector switches in the cover. Provide automatic alternator for duplex units.

2.5.3.2 Space Heating and Steam Loads or Distribution Lines

**********

**NOTE: For space heating loads only, delete this paragraph.**

**********

Provide condensate pump with an approved float-actuated valve or water feeder in the cold-water makeup connection either external to or integral with the receiver. Where a de-aerating feedwater heater is not included, control the condensate pumping unit automatically by a pump controller with low-water cutout on each boiler. Provide pump controller and low-water cutout with two float-operated mercury switches arranged to start and stop the condensate pump at preset boiler water levels. Use one switch to control the operation of the condensate pump by starting the pump when the water in the boiler reaches a preset low level and by stopping the pump when the water in the boiler rises to a preset high level. Use the second switch to ring an alarm bell and simultaneously shut down the burner. Provide relays if necessary. Install a minimum 100 mm 4 inch alarm bell with bell-ringing transformer where directed.

Install a gate valve and a check valve or a stop-check (nonreturn) valve in the feed line between the boiler and the pump adjacent to the boiler connection. Provide condensate pump motor with a magnetic, across-the-line starter equipped with thermal-overload protection conforming to the requirements of paragraph ELECTRICAL EQUIPMENT. Where two or more boilers are provided, install a pump controller and low-water cutout at the normal waterline of each boiler. Install an automatic feed valve in the feed line to each boiler. When any boiler requires water, the pump controller must open the feed valve by actuating an end switch which, in turn, operates the condensate pump. When the normal water level is restored, the pump controller must close the feed valve, and the end switch of the valve must stop the condensate pump.

2.5.3.3 Rating and Testing

Submit a certified test report covering the actual test of the unit and certifying that the equipment complies with the indicated requirements.

2.5.4 Vacuum Pumping Unit

**********
**NOTE: Delete this paragraph if hot water is utilized.**
**********

Provide vacuum pumping unit which is a combination air removal and condensate return unit consisting of [a single pump, electric motor, and receiving tank] [pumps, electric motors, and other functioning parts in duplicate and a single receiving tank] as indicated. Two interconnected single units will be acceptable in place of a duplex unit. Arrange the unit for automatic operation. Where duplicate pumps are used, one pump will serve as a standby. Where it is standard with the manufacturer, separate pumps may be used for air removal and condensate return if both pumps are mounted on a common receiver. Construcy the receiver of cast iron, or of no less than 4.75 mm 3/16 inch thick black iron or steel. Provide bronze pumping unit fitted throughout with bronze shafts or with shafts protected by bronze sleeves. Mount pumps, motors, and receiver on a single base and make provision for catching the drip from the stuffing boxes. Provide accessories consisting of a compound gauge, a pressure gauge inlet strainer, thermometer, water level gauge with stopcocks, adjustable vacuum relief valve, air discharge and condensate discharge check valves, and companion flanges for all flanged connections. Provide discharge line from each pump with a nonslam check valve and a globe valve. Provide each motor with a dripproof-type enclosure. Provide fully automatic controls for each pump motor. Provide controls consisting of a float in the receiving tank, a float switch, an adjustable vacuum switch, an automatic, magnetic, across-the-line type starter with general-purpose enclosure, and a three-position selector switch in the cover. The selector switch must provide for ["Automatic," "Float," "Vacuum,"] ["Automatic," "Float,"] and "Continuous" operation of the pump.

2.6 COLD WATER CONNECTIONS

Provide connections which include consecutively in line a strainer, reduced pressure principle backflow preventers, and water pressure regulator in that order in the direction of the flow. Provide reduced pressure principle backflow preventers as indicated and in compliance with Section 22 00 00 PLUMBING, GENERAL PURPOSE. Make cold water fill connections to the water supply system as indicated. Provide necessary

pipe, fittings, and valves required for water connections between the boiler and cold water main as shown. Provide pressure regulating valve of a type that will not stick or allow pressure to build up on the low side. Set the valve to maintain a terminal pressure of approximately 35 kPa 5 psi in excess of the static head on the system and operate within a 15 kPa 2 psi tolerance regardless of cold water supply piping pressure and without objectionable noise under any condition of operation.

## 2.7 RADIATORS AND CONVECTORS

Provide radiators, convectors and associated equipment in accordance with Section [23 57 10.00 10 FORCED HOT WATER HEATING SYSTEMS USING WATER AND STEAM HEAT EXCHANGERS] [23 58 00.00 10 CENTRAL STEAM HEATING AND UTILITIES SYSTEMS].

## 2.8 RADIANT FLOOR HEATING SYSTEMS

**********

**NOTE: Delete this paragraph if radiant floor heating systems are not required.**

**Although this specification deals with heating water produced by boilers, other sources of heat such as solar, domestic water heaters, waste heat, or heat pumps may also be used for radiant floor heating.**

**The radiant floor heating system should be designed in accordance with the latest edition of the ASHRAE Systems and Equipment Handbook, HI-004, and the Radiant Panel Association's (RPA) Standard Guidelines for the Design and Installation of Residential Radiant Panel Heating Systems.**

**All pipe layouts, zones, pipe sizes, and pump sizes should be clearly shown on the drawings. The designer should provide a cross sectional detail of the integrated floor and piping system that clearly shows the floor design. Floor insulation, floor coverings, floor load bearing characteristics, and manifold access panel should be coordinated with the architect and structural engineer. The method of insulating the floor is different from typical construction. If the insulation is not properly designed, the system will not work.**

**The drawings should also address the desired control sequence for the radiant heating system. The drawings should indicate which loops will require temperature control, in order for the manufacturer to provide a proper manifold. Various control strategies can be found in HYI 400 and the RPA standard guideline for the Design and Installation of Residential Radiant Panel Heating Systems. The control sequence should consider the required circulation of water through the boiler. High mass radiant floor heating systems do not typically respond quickly to a change in load due to the thermal mass of the floor. Therefore, night setback control is not feasible for high mass floor radiant**

**heating systems, unless long durations of unoccupied spaces occur such as in a chapel.**

**Radiant floor heating systems use lower water temperatures than standard convection heating. Therefore, the boiler may experience a water temperature that is lower than recommended by the boiler manufacturer. If this occurs due to the design and selection of boiler, a mixing valve or other control devices should be provided to maintain the recommended water temperature for the boiler.**

**Several floor designs can be used for radiant heating. The following examples indicate a few possibilities:**

**Slab-on-grade: typical concrete floor system with tubing imbedded in concrete.**

**Thin-slab system: tubing imbedded in a thin light weight concrete on top of a wooden sub-floor.**

**Above floor plate system: tubing installed in channels with reflective metal barriers above a wooden sub-floor. The tubing is then covered with thin sheets of plywood.**

**Below floor plate system: the tubing is installed below the wooden sub-floor using reflective metal barriers.**

**Below floor suspended tube system: the tubing is suspended within the interstitial space between a wooden sub-floor and insulation. (Seldom used due to higher water temperature requirements).**

**Below floor staple-up system: the tubing is stapled to the underside of a wooden sub-floor. This system is available; however, the below floor plate system is more energy efficient.**

**If outdoor air is required for ventilation, a separate make-up air system should be installed.**

**In accordance with the Standard Mechanical Code, the temperature of these heating systems should not exceed an operating temperature of 60 degrees C (125 degrees F), when the piping is used in gypsum assemblies.**

**********

Provide radiant floor heating system including all piping, manifolds, valves, pumps, expansion tank, pressure relief valves, and controls to provide a complete and operational heating system.

2.8.1 Tubing

Use tubing material in compliance with ASTM F876. Provide piping with a factory applied oxygen barrier with a diffusion rate that does not exceed

0.1 grams per cubic meter per day. The piping must be rated at 689 kPa 100 psi and 82.5 degrees C 180 degrees F.

2.8.2 Joints

Consult the manifold manufacturer to determine the proper joint for connection of tubing to the manifold. For joints required to connect the tubing to the manifold, provide compression type fittings using crimp rings, a combination of inserts and O-rings, gripper type fittings using a retainer ring and O-rings, or as otherwise recommended by the manifold and tubing manufacturer.

2.8.3 Manifold

Provide design and construction of the manifold that is compatible with the tubing manufacture's requirements. Provide piping manifold material that is compatible with the piping material. The manifold must be capable of providing the number of circuits as indicated on the drawings. The manifold must be suitable for an operating pressure of 689 kPa 100 psi and 82.5 degrees C 180 degrees F. Provide balancing valves for each circuit. Provide isolation valves for each supply and return connection. Provide each manifold with an air vent. Allow for the measurement of temperature for each circuit. Provide manifold with all required mounting hardware.

## 2.9 UNIT HEATERS

**********

**NOTE: Indicate capacity of unit heaters and heating and ventilating units on drawings. Show typical piping details on drawings for these units.**

**In critical areas where maximum noise level limits are required, the sentence in brackets will be retained and the brackets deleted. The maximum acceptable noise limits for these critical areas will be determined in NC level or dbA and should be indicated on the drawings. The sentence in brackets will be deleted for noncritical areas. Sound values will be selected by the designer based on a study of the design goal. The ASHRAE Handbook, Fundamentals, shows the range of sound pressure values for speech communications as being 50 dB for fair, 44 dB for very good, and 38 dB for perfect speech intelligibility.**

**********

Provide heaters as specified below, and with a heating capacity not in excess of 125 percent of the capacity indicated. [Noise level of each unit heater for areas noted must not exceed the criteria indicated.]

2.9.1 Propeller Fan Heaters

Design heaters for suspension and arrange for [horizontal] [vertical] discharge of air as indicated. Provide casings consisting of no less than 0.912 mm 20 gauge black steel and finished with lacquer or enamel. Provide suitable [stationary] [rotating air] deflectors to assure proper air and heat penetration capacity at floor level based on established design temperature. Suspension from heating pipes will not be permitted. [Operate fans for vertical discharge type heaters at speeds not in excess

of 1,200 rpm, except that units with 84.4 MJ 80,000 Btu output capacity or less may operate at speeds up to 1,800 rpm.] [Provide horizontal discharge type unit heaters with discharge or face velocities not in excess of the following]:

| Unit Capacity, L/s cfm | Face Velocity, m/s fpm |
|---|---|
| Up to 472 1000 | 4.06 800 |
| 473 to 1416 1,001 to 3,000 | 4.57 900 |
| 1417 3001 and over | 5.08 1,000 |

2.9.2 Centrifugal Fan Heaters

Arrange heaters for floor or ceiling mounting as indicated. House heating elements and fans in steel cabinets of sectionalized steel plates or reinforced with angle-iron frames. Construct cabinets of black steel no lighter than 1.27 mm 18 gauge. Provide each unit heater with a means of diffusing and distributing the air. Mount fans on a common shaft, with one fan to each air outlet. Equip fan shaft with self-aligning ball, roller, or sleeve bearings and accessible means of lubrication. Fan shaft may be either directly connected to the driving motor or indirectly connected by adjustable V-belt drive rated at 150 percent of motor capacity. All fans in any one unit heater must be the same size.

2.9.3 Heating Elements

**********
**NOTE: For project designs requiring air-supply and distribution systems, consider using the optional choice of referencing Section 23 30 00 HVAC AIR DISTRIBUTION for the equipment in this paragraph.**
**********

[Provide heating coils and radiating fins consisting of suitable nonferrous alloy with [threaded] [brazed] fittings at each end for connecting to external piping. Provide heating elements that are free to expand or contract without developing leaks and properly pitch for drainage. Test elements under a hydrostatic pressure of 1.38 MPa 200 psig and submit a certified report of the test to the Contracting Officer.] [Provide heating coils as specified in Section 23 30 00 HVAC AIR DISTRIBUTION for types indicated.] Ensure coils are suitable for use with water up to 121 degrees C 250 degrees F.

2.9.4 Motors

Provide motors with NEMA MG 1 open drip proof (ODP) [TEFC][_____] enclosure. Motors and motor controls must otherwise be as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.9.5 Motor Switches

Provide motors with manual selection switches with "Off," and "Automatic" positions and equip with thermal overload protection.

2.9.6 Controls

Provide controls as specified in Section 23 09 00 INSTRUMENTATION AND CONTROL FOR HVAC.

2.10 HEATING AND VENTILATING UNITS

Provide heating and ventilating units and associated equipment in accordance with Section 23 30 00 HVAC AIR DISTRIBUTION.

2.11 AIR HANDLING UNITS

Provide air handling units and associated equipment in accordance with Section 23 30 00 HVAC AIR DISTRIBUTION.

2.12 FITTINGS AND ACCESSORIES

Install boiler fittings and accessories with each boiler in accordance with ASME BPVC SEC IV, unless otherwise specified.

2.12.1 Soot Blowers

**********

**NOTE: Soot blowers will normally be required on large water tube units burning No. 5 or 6 fuel oil. Manufacturers of boilers should be consulted to determine if soot blowers are applicable for the design contemplated. Small units are usually manually cleaned.**

**********

Where indicated, provideeach boiler with soot blowers using [compressed air] [steam] as the blowing medium. Provide automatic sequencing and intermittent puff type soot blower system. Sequence the soot blower units automatically using successive steps by their controller, each step involving no more than a 70 kPa 10 psi drop in air pressure at the receiver. After one unit is operated in successive steps through its cycle, the controller must shift the operation to the second soot blower unit, and so on, until all units on that boiler have been operated, after which the controller must be shut down automatically by the sequence controls. Provide soot blower heads with elements of suitable material for the highest temperatures encountered in the boiler. The sequence timer must have provision for manual selection of the soot blower units to be used. Provide soot blower system for oil fired boilers conforming to NFPA 85.

2.12.1.1 Air Compressor Unit

Provide air compressor unit conforming to ASME PTC 10 except as specified otherwise. Do not exceed compressor speed of900 rpm. Do not exceed motor speed of 1750 rpm. Provide service air requirements as indicated with receivers sized as indicated. Provide units that are suitable for heavy-duty service (soot blowing). Use simplex type, single-stage, double-acting compressors, with water-jacketed cylinder, fitted with intake and discharge valves of the lightweight feather, disc or plate type, and provide with necessary controls, water-cooled aftercooler, moisture separator, drive, receiver, relief valves, and cooling water controls as required. Provide compressor air intake with an air suction filter/silencer suitable for outdoor installation. The filter must have a

collection efficiency of 99 percent of particles larger than 10 microns. The filter body and media must withstand a pressure of 850 kPa 125 psi. Provide shell-and-tube type aftercooler designed for air flow through the tubes with steel shell internal baffle plates. Size the cooling capacity of the after cooler for the total capacity of the compressor. Provide moisture separator with an automatic water discharge trap and level gauge. Provide thermostatic valve type cooling water controls for regulating compressor cylinder water temperature and after-cooler water temperature and install with a three-valve bypass in the water outlet lines ahead of open sight drain funnels. Equip compressor with adjustable, pressure type unloader controls suitable for continuous compressor operation.

2.12.1.2 Air Receiver

Provide a vertical type air receiver constructed in accordance with ASME BPVC SEC VIII D1 for unfired pressure vessels for 1379 kPa 200 psi working pressure, and equipd with flanged inlet and outlet connections, valved drain connection, minimum 150 mm 6 inch dial pressure gauge, pop safety valves, and regulator connections.

2.12.2 Continuous Emissions Monitoring

**********

**Emerging flue gas flow monitor technologies are available. The traditional differential pressure technique specified used familiar equipment that can be maintained by plant personnel. This type of measurement device has reliably satisfied regulatory requirements. The possible use of other technologies should include a thorough investigation of flue gas flow monitor regulatory requirements and inhouse maintenance capabilities.**

**********

a. Provide Continuous Emissions Monitoring System (CEMS) equipment as a system by a single manufacturer. Provide a CEMS, meeting the requirements of applicable federal, State of [_____] and local regulations, for each boiler in accordance with manufacturer's recommendations and under the direct supervision of the CEMS equipment manufacturer. Before acceptance of the installation, furnish the Contracting Officer a written test report which provides documentation that the CEMS equipment passed factory and field certification test required by federal, state, and local regulations. Submit written certification by the boiler manufacturer that each boiler furnished complies with Federal, state, and local regulations for emissions. Also include a description of applicable emission regulations. If any boiler is exempt from the emission regulations, indicate the reason for the exemption in the certification.

b. Include [sulfur dioxide (SO2)] [oxides of nitrogen (NOX)] [carbon dioxide (CO2)] [and] [particulate matter (PM)] and other information required by Federal, state, and local regulations in the reported data. Base SO2 reporting on [analyzer measurement] [fuel flow and percent sulfur calculation]. Base nitrous oxides, carbon dioxide and particulate matter reporting on analyzers.

c. The CEMS equipment includes the central processing unit, printer, hard disk drive, and floppy disk drive. The floppy disk drive must

function as a recorder. The manufacturer must provide the software to generate the required reports in a format acceptable to the Federal, state and local regulatory agencies. Provide operator interface to the CEMS equipment via CRT screen.

2.12.2.1 Gaseous Emission Monitors

Provide extractive or in situ gaseous monitors. A combination of extractive and in situ monitors is not acceptable. Include automatic calibration checks for gas monitors. Provide an alarm horn and annunciator to alarm when any monitor parameter is out of range or a gaseous monitor malfunctions. Construct surfaces that are exposed to the corrosive gas of the boiler of noncorrosive materials such as 316 SS, teflon or hastelloy.

a. Mount in situ monitor on the ductwork at the location [shown on the plans] [recommended by the manufacturer]. The situ system must not be affected by the presence of particulate matter in the flue gas.

b. Provide [wet] [dry] [diluted] extractive systems. Locate analyzing equipment for the extractive system in a walk-in cabinet. Arrange the equipment to provide access for maintenance. Heat trace extractive system sampling between the probes and the analyzers to maintain the temperature recommended by the manufacturer when the ambient temperature is [_____] degrees C F. Mount probes on the ductwork at the location [shown on the plans] [recommended by the manufacturer].

2.12.2.2 Flue Gas Flow Monitor

Flue gas flow monitor must utilize the pitot tube principle to measure the flow. Provide an across-the-duct-average pitot tube probe and design and locate to obtain representative measurement. Use differential pressure transmitters to sense the difference between the static and total pressure of the flowing gas steam. Ensure calibrations are stable. Arrange lines to prevent collection of condensate. Provide a purge system as required to keep the pitot pressure taps clear.

2.12.2.3 Particulate Matter Monitor

Provide particulate matter (opacity) monitor based on the principle of transmissometry. Provide transmissometer with automatic simulation of zero opacity and upscale check of calibration while the boiler is in service without dismounting the unit. Include analyzer internal circuitry and electronic circuitry in calibration check. Provide an alarm horn and annunciator to annunciate excess opacity and any system malfunction. Provide units with fans to keep the sending and receiving lenses pressurized and blown clean at all times.

2.12.2.4 Wiring

Provide CEMS equipment with plug-in prefabricated cable for interconnection between components. Provide 2-wire, 120 volt nominal or less, 60 Hz, power supply to the equipment with one side grounded. Connect electrical devices as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM.

2.12.3 Tankless Water Heater

**********

**NOTE: If the system will not be used to heat domestic hot water delete this paragraph.**
**********

Install a seamless copper immersion type tankless water heater of the specified capacity in the boiler. Equip the heater with an approved water-tempering valve which is set to supply hot water at approximately 60 degrees C 140 degrees F. Instead of the immersion type coil, an approved external shell and tube type or plate type heat exchanger may be installed as specified in Section 23 57 10.00 10 FORCED HOT WATER HEATING SYSTEMS USING WATER AND STEAM HEAT EXCHANGERS.

2.12.4 Conventional Breeching and Stacks

**********
**NOTE: Delete this paragraph for condensing boilers.**
**********

2.12.4.1 Breeching

Connect each boiler to the stack or flue by breeching constructed of black steel sheets no less than 1.2 mm 0.0478 inch thick nor less than thickness of stack, whichever is larger. Plastic materials polyetherimide (PEI) and polyethersulfone (PES) are forbidden to be used for vent piping of combustion gases. The clear distance between any portion of the breeching surface and any combustible material must not be less than that specified in NFPA 211. Fasten joints and seams securely and make airtight. Provide suitable hinged and gasketed cleanouts, which will permit cleaning the entire smoke connection without dismantling. Provide flexible-type expansion joints as required and do not require packing.

2.12.4.2 Stacks

**********
**NOTE: Frequently boiler outlets are designed to support no more than the weight of a 6 m 20 foot stack section, when installed directly above the boiler outlet. Ensure that the stack is properly supported.**
**********

[Extend individual stub stacks above the roof to the heights indicated. Use individual stub stacks that are [6] [_____] m [20] [_____] feet in height when assembled on the boiler and measured from the ground line. Provide sheet steel stack section having a thickness of no less than 2.47 mm 0.0972 inch.] [Extend prefabricated double wall stacks system above the roof to the height indicated. Provide stacks that are [6] [_____] m [20] [_____] feet in height when assembled on the boiler and measured from the ground line. Provide inner stack consisting of [304 stainless steel] [316 stainless steel] having a thickness of no less than 0.89 mm 0.035 inch. Provide outer stack consisting of sheet steel having a thickness of no less than 0.635 mm 0.025 inch. Incorporate a method of maintaining concentricity between the inner and outer stacks. Seal the joints between the stack sections to prevent flue gas leakage.] Provide a 7.92 mm 0.3125 inch diameter hole in the stack no greater than 150 mm 6 inches from the furnace flue outlet for sampling of the exit gases. Provide a method to seal the hole to prevent exhaust gases from entering the boiler room when samples are not being taken. Provide each stack complete with rain hood. Plastic materials polyetherimide (PEI) and polyethersulfone (PES) are

forbidden to be used for vent piping of combustion gases.

2.12.5 Direct Vents

**********

**NOTE: Delete this paragraph if condensing boilers are not used. A conventional stack is not needed for condensing boilers due to the low exhaust air temperature. Precautions should be taken due to the acidic condition of the condensate. The location and size of the vents should be shown on the drawings. Consult NFPA 54, UL 1738, and available vendor data to design the vents. The vents can be mounted on the roof or exterior wall with proper separation. The vents should be extended above the typical snow level. Vents should be located in such a manner as to prevent vandalism and to prevent discharge of condensate across walkways.**

**********

Use direct venting for condensing type boilers. Size and locate the air intake and exhaust vents as indicated on the drawings and as recommended by the boiler manufacturer. Provide a separate combustion air intake vent and exhaust vent for each boiler.

2.12.5.1 Combustion Air Intake Vent

Construct the combustion air intake piping of Schedule 40 PVC in accordance with ASTM D1784. Provide vent that is suitable for the temperature at the boiler combustion air intake connection point. Provide each intake complete with bird screen.

2.12.5.2 Exhaust Vent

Construct the exhaust vent piping of Schedule 40 CPVC or stainless steel conforming to UL 1738 and the boiler manufacturer's recommendations. Plastic materials polyetherimide (PEI) and polyethersulfone (PES) are forbidden to be used for vent piping of combustion gases. Provide exhaust vent that is suitable for the maximum anticipated boiler exhaust temperature and withstands the corrosive effects of the condensate. Provide a 8 mm 0.3125 inch diameter hole in the stack no greater than 152 mm 6 inches from the boiler flue outlet for sampling of the exit gases. Provide a method to seal the hole to prevent exhaust gases from entering the boiler room when samples are not being taken. Provide each exhaust stack complete with bird screen.

2.12.6 Expansion Tank

**********

**NOTE: If a hot water heating system is not utilized delete this paragraph.**

**********

Provide hot water pressurization system including a diaphragm-type expansion tank which will accommodate the expanded water of the system generated within the normal operating temperature range, limiting the pressure increase at all components in the system to the maximum allowable pressure at those components. The only air in the system will be the permanent sealed-in air cushion contained in the diaphragm-type tank.

Provide sizes as indicated. Provide welded steel expansion tank, constructed, tested, and stamped in accordance with ASME BPVC SEC VIII D1 for a working pressure of [850] [_____] kPa [125] [_____] psi and precharged to the minimum operating pressure. Fit the tank's air chamber with an air charging valve and pressure gauge. Support the tank by steel legs or bases for vertical installation or steel saddles for horizontal installations. Provide lifting rings and a drain connection for the tank. All components must be suitable for a maximum operating temperature of 120 degrees C 250 degrees F.

2.12.7 Air Separator

Provide steel external air separation tank, constructed, tested and stamped in accordance with ASME BPVC SEC VIII D1 for a working pressure of [850] [_____] kPa [125] [_____] psi. The capacity of the air separation tank indicated is minimum.

2.12.8 Filters

Provide filters conforming to ASHRAE 52.2.

2.12.9 Foundation (Setting) Materials

2.12.9.1 Firebrick

Provide ASTM C27 class firebrick as recommended by boiler manufacturer.

2.12.9.2 Tile

Provide ASTM C34, Grade LBX tile.

2.12.9.3 Insulating Brick

Provide insulating brick complying with ASTM C155.

2.12.9.4 Refractory Mortar

Provide refractory mortar complying with ASTM F1097.

2.12.9.5 Castable Refractories

Castable refractories must be ASTM C401. The minimum modulus of rupture for transverse strength must be no less than 4136 kPa 600 psi after being heat soaked for 5 hours or more at a temperature in excess of 1371 degrees C 2500 degrees F.

2.12.10 Steel Sheets

2.12.10.1 Galvanized Steel

Galvanized steel must be ASTM A653/A653M.

2.12.10.2 Uncoated Steel

Use uncoated steel which is composition, condition, and finish best suited to the intended use.

2.12.11 Gaskets

Provide gaskets consisting of nonasbestos material in accordance with ASME B16.20, full face or self-centering type. Provide gaskets spiral wound type gaskets with graphite filler material.

2.12.12 Steel Pipe and Fittings

2.12.12.1 Steel Pipe

Steel pipe must be ASTM A53/A53M, Type E or S, Grade A or B, black steel, standard weight.

2.12.12.2 Steel Pipe Fittings

Affix the manufacturer's trademark to fittings in accordance with MSS SP-25 to permanently identify the manufacturer.

2.12.12.3 Steel Flanges

Provide flanged fittings including items such as flanges, bolts, nuts, bolt patterns, in accordance with ASME B16.5 class 150 and have the manufacturer's trademark affixed in accordance with MSS SP-25. Provide flange material conforming to ASTM A105/A105M. Use serrated or raised-face type flanges for high temperature water systems. Provide blind flange material conforming to ASTM A516/A516M cold service and ASTM A515/A515M for hot service. Provide high strength or intermediate strength bolts with material conforming to ASTM A193/A193M. Submit written certification by the bolt manufacturer that the bolts furnished comply with the requirements of this specification. Include illustrations of product markings, the date of manufacture, and the number of each type of bolt to be furnished based on this certification.

2.12.12.4 Welded Fittings

Provide welded fittings conforming to ASTM A234/A234M with WPA marking. Provide buttwelded fittings conforming to ASME B16.9, and socket-welded fittings conforming to ASME B16.11.

2.12.12.5 Cast-Iron Fittings

Provide ASME B16.4, Class 125, type fittings required to match connecting piping.

2.12.12.6 Malleable-Iron Fittings

Provide ASME B16.3, type fittings as required to match connecting piping.

2.12.12.7 Unions

Provide ASME B16.39, Class 150 unions.

2.12.12.8 Threads

Provide pipe threads conforming to ASME B1.20.2MASME B1.20.1.

2.12.12.9 Grooved Mechanical fittings

**********

**NOTE: Grooved mechanical fittings will not be allowed for steam piping or condensate piping or hot water piping above 110 degrees C 230 degrees F.**
**********

Design joints and fittings for no less than[ 862 kPa 125 psig] [_____] service, and ensure joints and fittings are the products of the same manufacturer. Provide ductile iron fitting and coupling houses conforming to ASTM A536. Provide molded synthetic rubber gaskets with central cavity, pressure responsive configuration and conforming to ASTM D2000 for circulating medium up to 110 degrees C 230 degrees F. Provide grooved joints conforming to AWWA C606. Provide steel coupling nuts and bolts conforming to ASTM A183.

2.12.13 Copper Tubing and Fittings

2.12.13.1 Copper Tubing

Provide ASTM B88M ASTM B88, Type K or L tubing. Use brass or bronze adapters for copper tubing for brazed fittings.

2.12.13.2 Solder-Joint Pressure Fittings

Provide wrought copper and bronze solder-joint pressure fittings conforming to ASME B16.22 and ASTM B75/B75M. Provide cast copper alloy solder-joint pressure fittings conforming to ASME B16.18 and ASTM B828.

2.12.13.3 Flared Fittings

Provide cast copper alloy fittings for flared copper tube conforming to ASME B16.26 and ASTM B62.

2.12.13.4 Adapters

Adapters may be used for connecting tubing to flanges and to threaded ends of valves and equipment. Extracted brazed tee joints produced with an acceptable tool and installed as recommended by the manufacturer may be used.

2.12.13.5 Threaded Fittings

Provide cast bronze threaded fittings conforming to ASME B16.15.

2.12.13.6 Brazing Material

Use brazing material conforming to AWS A5.8/A5.8M.

2.12.13.7 Brazing Flux

Provide paste or liquid form flux appropriate for use with brazing material. Flux must be as follows: lead-free; have a 100 percent flushable residue; contain slightly acidic reagents; contain potassium borides, and contain fluorides. Use silver brazing materials in accordance with AWS A5.8/A5.8M.

2.12.13.8 Solder Material

Provide solder metal conformig to ASTM B32 95-5 tin-antimony.

2.12.13.9 Solder Flux

Flux must be either liquid or paste form, non-corrosive and conform to ASTM B813.

2.12.13.10 Grooved Mechanical Fittings

**********
**NOTE: Grooved mechanical fittings will not be allowed for steam piping or condensate piping or hot water piping above 110 degrees C 230 degrees F.**
**********

Design joints and fittings for no less than [862 kPa 125 psig] [_____] service, and ensure joints and fittings are the products of the same manufacturer. Provide ductile iron fitting and coupling houses conforming to ASTM A536. Provide molded synthetic rubber gaskets with central cavity, pressure responsible configuration and conforming to ASTM D2000, for circulating medium up to 110 degrees C 230 degrees F. Provide grooved joints conforming to AWWA C606. Provide steel coupling nuts and bolts conforming to ASTM A183.

2.12.14 Dielectric Waterways and Flanges

Provide dielectric waterways that have temperature and pressure rating equal to or greater than that specified for the connecting piping. Provide waterways with metal connections on both ends suited to match connecting piping. Include dielectric unions to prevent current flow between dissimilar metals. Use dielectric flanges meeting the performance requirements described herein for dielectric waterways.

2.12.15 Flexible Pipe Connectors

Design flexible pipe connectors for 861.8 kPa 125 psi or 1034.2 kPa 150 psi service. Install connectors where indicated. Construct the flexible section of rubber, tetrafluoroethylene resin, or corrosion-resisting steel, bronze, monel, or galvanized steel. Use materials and configuration suitable for the pressure, vacuum, and temperature medium. The flexible section must be suitable for service intended and may have threaded, welded, soldered, flanged, or socket ends. Equip flanged assemblies with limit bolts to restrict maximum travel to the manufacturer's standard limits. Unless otherwise indicated, the length of the flexible connectors must be as recommended by the manufacturer for the service intended. Provide internal sleeves or liners, compatible with circulating medium, when recommended by the manufacturer. Provide covers to protect the bellows where indicated.

2.12.16 Pipe Supports

Provide pipe supports conforming to MSS SP-58.

2.12.17 Pipe Expansion

2.12.17.1 Expansion Loops

**********
**NOTE: Whenever possible, utilize expansion loops, offsets, and bends instead of expansion joints to absorb and to compensate for expansion and**

**contraction. Coordination will be made with seismic bracing. Seismic bracing should not interfere with thermal expansion.**
**********

Expansion loops and offsets must provide adequate expansion of the main straight runs of the system within the stress limits specified in ASME B31.1. Provide cold-sprung loops and offsets and install where indicated. Provide pipe guides and anchors as indicated.

2.12.17.2 Expansion Joints

Expansion joints must provide for either single or double slip of the connected pipes, as required or indicated, and for no less than the transverse indicated. Design joints for a [hot water] [steam] working pressure no less than [_____] kPa psig and in accordance with applicable requirements of EJMA Stds and ASME B31.1. Provide flanged end connection. Providee anchor bases or support bases as indicated or required. Sliding surfaces and water wetted surfaces must be chromium plated or fabricated of corrosion resistant steel. Make initial setting in accordance with the manufacturer's recommendations to compensate for an ambient temperature at time of installation. Install pipe alignment guides as recommended by the joint manufacturer, but in any case do not install pipe alignment guides more than 1.5 m 5 feet from expansion joint, except in lines 100 mm 4 inches or do not install smaller guides more than 600 mm 2 feet from the joint. Provide service outlets where indicated.

2.12.17.2.1 Bellows-Type joint

Provide bellows-type joints that are flexible, guided expansion joints. Provide expansion element consisting of stabilized corrosion resistant steel. Provide bellows-type expansion joints conforming to the applicable requirements of EJMA Stds and ASME B31.1 with internal lines. Guiding of piping on both sides of expansion joint must be in accordance with the published recommendations of the manufacturer of the expansion joint. Design joints for the working temperature and pressure suitable for the application but no less than 1135 kPa 150 psig.

2.12.17.2.2 Flexible Ball Joint

Construct flexible ball joints of alloys as appropriate for the service intended. Provide threaded, grooved, flanged, or welded end joints as required that are capable of absorbing the normal operating axial, lateral, or angular movements or combination thereof. Provide polished, chromium-plated balls and sockets when materials are not of corrosion-resistant steel. Design and construct ball type joint in accordance with ASME B31.1 and EJMA Stds. Provide flanges conforming to the diameter and drilling of ASME B16.5. Provide molded gaskets suitable for the service intended.

2.12.17.2.3 Slip Type Expansion Joint

Provide EJMA Stds and ASME B31.1, Class 1 or 2 slip type expansion joints. Provide Type II joints which are suitable for repacking under full line pressure.

2.12.18 Valves

Provide Class 125 valves that are suitable for the application. Grooved

ends in accordance with AWWA C606 may be used for water service only. Provide valves in nonboiler external piping meeting the material, fabrication and operating requirements of ASME B31.1. The connection type of all valves must match the same type of connection required for the piping on which installed.

2.12.18.1 Gate Valves

Provide gate valves 65 mm 2-1/2 inches and smaller conforming to MSS SP-80 bronze rising stem, threaded, solder, or flanged ends. Provide gate valves 80 mm 3 inches and larger conforming to MSS SP-70 cast iron bronze trim, outside screw and yoke, flanged, or threaded ends.

2.12.18.2 Globe Valves

Provide globe valves 65 mm 2-1/2 inches and smaller conforming to MSS SP-80, bronze, threaded, soldered, or flanged ends. Provide globe valves 80 mm 3 inches and larger conforming to MSS SP-85, cast iron, bronze trim, flanged, or threaded ends.

2.12.18.3 Check Valves

Provide check valves 65 mm 2-1/2 inches and smaller conforming to MSS SP-80, bronze, threaded, soldered, or flanged ends. Provide check valves 80 mm 3 inches and larger conforming to MSS SP-71, cast iron, bronze trim, flanged, or threaded ends.

2.12.18.4 Angle Valves

Provide angle valves 65 mm 2-1/2 inches and smaller conforming to MSS SP-80 bronze, threaded, soldered, or flanged ends. Provide angle valves 80 mm 3 inches and larger conforming to MSS SP-85, cast iron, bronze trim, flanged, or threaded ends.

2.12.18.5 Ball Valves

Provide ball valves 15 mm 1/2 inch and larger conforming to [MSS SP-72] [or] [MSS SP-110], ductile iron or bronze, threaded, soldered, or flanged ends.

2.12.18.6 Plug Valves

Provide plug valves 51 mm 2 inch and larger conforming to MSS SP-78. Provide plug valves smaller than 51 mm 2 inch conforming to ASME B16.34.

2.12.18.7 Grooved End Valves

**********

**NOTE: Grooved end valves will not be allowed for steam piping.**

**********

Valves with grooved ends in accordance with AWWA C606 may be used if the valve manufacturer certifies that their performance meets the requirements of the standards indicated for each type of valve.

2.12.18.8 Balancing Valves

Provide balancing valves that have meter connections with positive shutoff

valves. Provide an integral pointer to register the degree of valve opening. Calibrate valves so that flow rate can be determined when valve opening in degrees and pressure differential across valve is known. Construct each balancing valve with internal seals to prevent leakage and supply with preformed insulation. Provide valves that are suitable for 120 degrees C 250 degrees F temperature and working pressure of the pipe in which installed. Provide valve bodies with tapped openings and pipe extensions with shutoff valves outside of pipe insulation. Provide pipe extensions with quick connecting hose fittings for a portable meter to measure the pressure differential. Furnish one portable differential meter. Provide meter suitable for the operating pressure specified complete with hoses, vent, and shutoff valves, and carrying case. In lieu of the balancing valve with integral metering connections, a ball valve or plug valve with a separately installed orifice plate or venturi tube may be used for balancing.

2.12.18.9 Automatic Flow Control Valves

**********

**NOTE: In any facility where technological and occupancy requirements indicate that load imbalances cannot be tolerated and there is a need for automatic control ensuring constant hydronic flow, the design will incorporate automatic flow-control valves indicating their location and capacity on the drawings. The required pump head will be shown on the drawings.**

**Utilize electric motor controls for new systems; thus, delete bracketed selection "or pneumatic type as applicable" for projects involving new systems.**

**********

In lieu of the specified balancing valves, automatic flow control valves may be provided to maintain constant flow and designed to be sensitive to pressure differential across the valve to provide the required opening. Select valves for the flow required and provide with a permanent nameplate or tag carrying a permanent record of the factory-determined flow rate and flow control pressure levels. Control the flow within 5 percent of the tag rating. Ensure valves are suitable for the maximum operating pressure of 850 kPa 125 psi or 150 percent of the system operating pressure, whichever is greater. Where the available system pressure is not adequate to provide the minimum pressure differential that still allows flow control, increase the system pump head capability. Ensure alves are suitable for 120 degrees C 250 degrees F temperature service. Use vavlve materials that are the same as specified for the heating system check, globe, angle, and gate valves. Provide electric motor type[ or pneumatic type as applicable] valve operator. Provide valve operator that is capable of positive shutoff against the system pump head. Provide valve bodies with tapped openings and pipe extensions with shutoff valves outside of pipe insulation. Provide pipe extensions with quick connecting hose fittings for a portable meter to measure the pressure differential across the automatic flow control valve. Provide a portable meter with accessory kit as recommended for the project by the automatic valve manufacturer.

2.12.18.10 Butterfly Valves

Provide 2-flange type or lug wafer type butterfly valves, and make

bubbletight at 1135 kPa 150 psig. Provide valve bodies consisting of cast iron, malleable iron, or steel. Provide ASTM A167, Type 404 or Type 316, corrosion resisting steel stems, bronze, or corrosion resisting steel discs, and synthetic rubber seats. Valves smaller than 200 mm 8 inches must have throttling handles with a minimum of seven locking positions. Valves 200 mm 8 inches and larger must have totally enclosed manual gear operators with adjustable balance return stops and position indicators. Provide valves in insulated lines with extended neck to accommodate insulation thickness.

2.12.18.11 Drain valves

Provide drain valves at each drain point of blowdown as recommended by the boiler manufacturer. Provide piping conforming to ASME BPVC SEC IV and ASTM A53/A53M.

2.12.18.12 Safety Valves

Provide safety valves with steel bodies and equip with corrosion-resistant trim and valve seats. The valves must be properly guided and positive closing so that no leakage can occur. Adjustment of the desired back-pressure must cover the range between 15 and 70 kPa 2 and 10 psig. Make the adjustment externally, and provide any shafts extending through the valve body with adjustable stuffing boxes having renewable packing. Install boiler safety valves of proper size and of the required number, in accordance with ASME BPVC SEC IV, so that the discharge will be through piping extended [to the blowoff tank] [to a location as indicated]. [Provide each discharge pipe for steam service with a drip pan elbow to prevent accumulation of water on the valve. Provide a slip joint between drip pan elbow and riser.] [Pitch each discharge pipe for hot water service away from the valve seat.]

2.12.19 Strainers

Provide basket and "Y" type strainers which are the same size as the pipelines in which they are installed. Provide strainer bodies that are heavy and durable, fabricated of cast iron, and drill and tap bottoms with a gate valve attached for blowdown purposes. Design strainers for [_____] kPa psig service and [_____] degrees C degrees F. Clearly cast arrows on the sides of bodies indicating the direction of flow. Equip each strainer with an easily removable cover and sediment screen. Make the screen of 0.795 mm 22 gauge thick [brass sheet] [monel] [corrosion-resistant steel] with small perforations numbering not less than 6,150/square m 400/square inch to provide a net free area through the basket of at least 3.30 times that of the entering pipe. The flow must be into the screen and out through the perforations.

2.12.20 Pressure Gauges

Provide gauges conforming to ASME B40.100 with throttling type needle valve or a pulsation dampener and shutoff valve. Provide minimum dial sizeof 90 mm 3-1/2 inches. Provide a pressure gauge for each boiler in a visible location on the boiler. Provide pressure gauges with readings in kPa psi. Provide pressure gauges with an indicating pressure range that is related to the operating pressure of the fluid in accordance with the following table:

| Operating Pressure (kPa) (psi) | Pressure Range (kPa) (psi) |
|---|---|
| 519-1030 76-150 | 0-1400 0-200 |
| 105-518 16-75 | 0-690 0-100 |
| 14-104 2-15 | 0-210 0-30 (retard) |

2.12.21 Thermometers

Provide thermometers with wells and separable corrosion-resistant steel sockets. Do not use mercury in thermometers. Provide thermometers for [inlet water and outlet water for each hot water boiler] [the feedwater for each steam boiler] in a visible location on the boiler. Provide thermometers with brass, malleable iron, or aluminum alloy case and frame, clear protective face, permanently stabilized glass tube with indicating-fluid column, white face, black numbers, and a minimum 225 mm 9 inch scale. The operating range of the thermometers must be 0-100 degrees C 32-212 degrees F. Provide thermometers with readings in degrees C F.

2.12.22 Air Vents

**********

**NOTE: Air vent locations will be indicated on drawings; distinguish between manual and automatic air vents.**

**********

2.12.22.1 Manual Air Vents

Manual air vents must be brass or bronze valves or cocks suitable for the pressure rating of the piping system and furnished with threaded plugs or caps.

2.12.22.2 Automatic Air Vents

Automatic air vents must be 19 mm 3/4 inch quick-venting float and vacuum air valves. Provide each air vent valve with a large port permitting the expulsion of the air without developing excessive back pressure, a noncollapsible metal float which will close the valve and prevent the loss of water from the system, an air seal that will effectively close and prevent the re-entry of air into the system when subatmospheric pressures prevail therein, and a thermostatic member that will close the port against the passage of steam from the system. Clearly stamp the name of the manufacturer on the outside of each valve. Ensure the air vent valve is suitable for the pressure rating of the piping system.

2.12.23 Steam Traps

**********

**NOTE: The design engineer, when designating steam using equipment or special steam applications, will indicate the type of steam trap required in accordance with the following data:**

**a. Inverted Bucket Traps: This type of trap continuously vents air and carbon dioxide at steam**

**temperature and is recommended for modulating loads. The bucket floats on steam to close the outlet and sinks into condensate to open the condensate outlet. Any trapped air is discharged first into the condensate return line and is followed by condensate discharge. This type of trap has the longest life on systems under modulated control. When large amounts of air are anticipated, an external thermostatic air vent should be installed on a line bypassing the trap to bleed air from the steam line and discharge it to the condensate return line. This system will give optimum performance at low steam pressures with maximum dependability. These traps will handle condensate from fan coil units where condensate must be lifted to return lines located above the equipment. They operate best at near full load conditions where loads do not vary over a wide range. Before operation, traps must be primed by filling them with water.**

**b. Vertical Open-Top Bucket Trap: Trap construction is more complex than inverted bucket type but is suitable for applications having wide variation of load and pressure and is recommended for constant pressure systems. Bucket sinks into condensate when condensate reaches top of trap and the discharge port opens. After discharge, the bucket floats on incoming condensate keeping the discharge port closed.**

**c. Impact-Operated Traps: These traps depend on steam velocity to keep the disc closed. As steam velocity decreases, the disc lifts off the seat and allows flow of condensate. These traps allow some steam leakage and do not vent air at low pressure. They are not recommended for service lower than 69 kPa (10 psig) or where back pressure may exceed 50 percent of inlet pressure. These traps are less expensive and have poor performance in the presence of dirt.**

**d. Thermostatic Traps: These traps are bellows-actuated and contraction of bellows at a few degrees below saturated steam pressure allows condensate air and noncondensable gases to be discharged. As steam reaches the bellows the expansion of the bellows closes the discharge port. These traps can also be utilized to vent air from a steam system and can be used in conjunction with an inverted bucket steam trap previously described.**

**e. Float and Thermostatic Trap: These traps provide optimum performance on modulating systems at lowest first cost. Where steam pressures modulate down to zero, large amounts of air may be liberated. They are ideal for dripping ends of steam risers, heels of up-feed steam risers, bottoms of down-feed stem risers. These traps are also**

**ideal for fan coil units and unit heaters.**

**f. Any trap selected must be sized for the expected condensate load with an applicable safety factor applied for the particular type of equipment serviced. Manufacturer's application manuals should be consulted to assist in sizing traps. Safety factors vary from 2:1 to 10:1. An average 3:1 safety factor value will cover most applications.**

**g. Service life between repairs or replacement of traps may be a determining factor in the choice of traps. One manufacturer of all types of traps offers the following experience record:**

| Type of Trap | Average Service Life Between Replacement or Repairs (months) |
|---|---|
| Inverted bucket traps | 42 |
| Float and thermostatic traps | 24 |
| Thermostatic traps | 24 |
| Impact-operated traps | 19 |

**********

2.12.23.1 Thermostatic Traps

Provide thermostatic traps conforming to the requirements of ASTM F1139 and install in the return connection from each radiator and elsewhere as indicated. Install drip traps for mains, risers, and similar lines with a cooling leg of 1.50 m 5 feet of uncovered 19 mm 3/4 inch pipe. Base capacity of traps a pressure differential of 15 kPa 2 psi. Design traps for a steam working pressure of 100 kPa 15 psig but operate with a supply pressure of approximately 15 kPa 2 psig. The traps must be angle or straight-through pattern with union inlet connections as indicated. Provide brass trap bodies and covers. Valve mechanisms and seats must be monel, stainless steel or hard bronze and removable for servicing or replacement.

2.12.23.2 Float-and-Thermostatic Traps

Provide float-and-thermostatic traps conforming to the requirements of ASTM F1139 and design for a steam working pressure of 100 kPa 15 psig but operate with a supply pressure of approximately 34 kPa 5 psig. Base trap capacity on a pressure differential of 15 kPa 2 psig. Provide each float-and-thermostatic trap with a cast iron body and provide with a hard bronze, monel, or corrosion-resisting steel valve seat and mechanism, an open- or closed-type float of brass or equally corrosion-resistant metal, and a corrosion-resisting steel thermostatic air vent, all of which can be easily removed for inspection or replacement without disturbing the piping connections. The inlet to each trap must have a brass or stainless steel strainer, either as an integral part of the trap or as a separate item of equipment.

2.12.23.3 Inverted Bucket Traps

Provide inverted bucket traps conforming to the requirements of ASTM F1139 and design for a steam working pressure of 100 kPa 15 psig but operate with a supply pressure of approximately 35 kPa 5 psig. Provide each trap with a cast iron body and a corrosion-resistant steel valve and seat and a brass or corrosion-resistant steel bucket, all of which can be easily removed for inspection or replacement without disturbing the piping connections. The inlet to each trap must have a brass or stainless steel strainer, either as an integral part of the trap or as a separate item of equipment.

2.13 ELECTRICAL EQUIPMENT

**********

**NOTE: Select standard efficiency for motors used less than 750 hours per year and high efficiency for motors used over 750 hours per year. The efficiency of each motor will be indicated in the equipment schedules.**

**********

Provide electric motor-driven equipment complete with motors, motor starters, and necessary control devices. Provide electrical equipment, motor control devices, motor efficiencies and wiring as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Ensure motors which are not an integral part of a packaged boiler and which are integral in size are the premium efficiency type in accordance with NEMA MG 1. Ensure motors which are an integral part of the packaged boiler are the highest efficiency available by the manufacturer of the packaged boiler. Provide motor starters complete with properly sized thermal overload protections and other appurtenances necessary for the motor control specified. Furnish starters in [general purpose][watertight][explosion-proof, Class I, division I] enclosures. Provide manual or automatic control and protective or signal devices required for the operation specified and any control wiring required for controls and devices that are not shown.

2.13.1 Motor Ratings

Motors must be suitable for the voltage and frequency provided. Motors 375 W 1/2 hp and larger must be three-phase, unless otherwise indicated. Provide motors of sufficient capacity to drive the equipment at the specified capacity without exceeding the nameplate rating on the motor.

2.13.2 Motor Controls

**********

**NOTE: Coordinate motor controls properly with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Coordinate with the electrical designer for power factors, service factors, and desired type of control.**

**********

Provide motor controllers complete with properly sized thermal overload protection. Provide manual or automatic control and protective or signal devices required for the operation specified and any wiring required to such devices. Where two-speed or variable-speed motors are indicated, solid-state variable-speed controllers may be provided to accomplish the

same function. Utilize solid state variable speed controllers for fractional through 7.46 kW 10 hp ratings. Use adjustable frequency drives for larger motors.

## 2.14 INSULATION

Use shop and field-applied insulation as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

## 2.15 TOOLS

Furnish special tools. Include uncommon tools necessary for the operation and maintenance of boilers, burners, pumps, fans, controls, meters, special piping systems, and other equipment. Furnish small hand tools within a suitable cabinet, mounted where directed.

### 2.15.1 Breeching Cleaner

Provide a cleaner to clean the breeching. The cleaner must have a jointed handle of sufficient length to clean the breeching without dismantling.

### 2.15.2 Tube Cleaner

If a watertube boiler is being furnished, provide a water-driven tube cleaner with three rotary cutters and rotary wire brush complete with the necessary length of armored water hose, valves, and other appurtenances necessary for operation. Provide tube cleaner and rotary brush for each size of water tube in the boiler, with one extra set of cutters for each size cleaner. Provide necessary valves and fittings to permit ready connection of the cleaner hose to a high-pressure pump for cold water supply to operate the cleaner.

### 2.15.3 Tube Brush

If a firetube boiler is being furnished, provide a tube brush, with steel bristles and jointed handle of sufficient length to clean full length of firetubes.

### 2.15.4 Wrenches

Provide wrenches as required for specialty fittings such as manholes, handholes, and cleanouts. Provide one set of extra gaskets for all manholes and handholes, for pump barrels, and other similar items of equipment. Package and properly identify gaskets.

## 2.16 FUEL OIL STORAGE SYSTEM

Provide fuel oil storage system as specified in Section 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS unless noted otherwise. Provide a [helical wound coil constructed of 25 mm 1 inch seamless steel tubing] [platecoil suction bell heater constructed of carbon steel no lighter than 1.9 mm (14 gauge) 14 gauge] in each tank for No. 6 fuel oil and install around the suction end of the oil line. Provide coil in each tank with capacity to heat the fuel oil from [_____] to [_____] degrees C degrees F, during the maximum demand of all oil burners connected to the tank. The coil must utilize [steam at [_____] kPa psig] [hot water at [_____] degrees C degrees F] as the heating medium. Attach the heating coil inlet and outlet connections and the fuel-oil suction and return piping connections to the same tank manway cover. Provide an additional manhole

located above the heater for removal of the heater as a unit.

## 2.17 BOILER WATER TREATMENT

**********

**NOTE: The chemical piping will be indicated on the drawing. Piping for external chemicals will be connected to the boiler feedwater. Piping for internal chemicals will be connected to the boiler drum. If steam is used for cooking or humidification, a separate heat exchanger will be required due to environmental constraints with the use of amines. The following items will not be required for hot water boilers: water softening system, chemical feed pumps, tanks, injection assemblies, water meters, water treatment control panel, and sequence of operation. The chemical shot feeder will not be required for steam boilers.**

**********

Submit [six] [_____] complete copies of the proposed water treatment plan. Include a layout, control scheme, a list of the existing water conditions including the items listed in this paragraph, a list of all chemicals, the proportion of chemicals to be added, the final treated water conditions, and a description of environmental concerns for handling the chemicals. The water treatment system must be capable of feeding chemicals and bleeding the system to prevent corrosion and scale within the boiler and piping distribution system. Submit [6] [_____] complete copies of operating and maintenance manuals for the step-by-step water treatment procedures, including procedures for testing the water quality. Treat the water to maintain the conditions recommended by the boiler manufacturer. Provide chemicals meeting required federal, state, and local environmental regulations for the treatment of boilers and discharge to the sanitary sewer. Use the services of a company regularly engaged in the treatment of boilers to determine the correct chemicals and concentrations required for water treatment. The company must maintain the chemical treatment and provide all chemicals required for a period of 1 year from the date of occupancy. Do not use filming amines and proprietary chemicals. The water treatment chemicals must remain stable throughout the operating temperature range of the system and must be compatible with pump seals and other elements of the system.

### 2.17.1 MakeUp Water Analysis

**********

**NOTE: A water analysis may be available from the user. If an analysis is not available, an analysis will be performed during the design, and appropriate data will be entered.**

**********

The makeup water conditions reported as prescribed in ASTM D596 are as follows:

| | |
|---|---|
| Date of Sample | [_____] |

| | |
|---|---|
| Temperature | [_____] degrees C degrees F |
| Silica (SiO2) | [_____] ppm (mg/1) |
| Insoluble | [_____] ppm (mg/1) |
| Iron and Aluminum Oxides | [_____] ppm (mg/1) |
| Calcium (Ca) | [_____] ppm (mg/1) |
| Magnesium (Mg) | [_____] ppm (mg/1) |
| Sodium and Potassium (Na and K) | [_____] ppm (mg/1) |
| Carbonate (HCO3) | [_____] ppm (mg/1) |
| Sulfate (SO4) | [_____] ppm (mg/1) |
| Chloride (C1) | [_____] ppm (mg/1) |
| Nitrate (NO3) | [_____] ppm (mg/1) |
| Turbidity | [_____] ntu |
| pH | [_____] |
| Residual Chlorine | [_____] ppm (mg/1) |
| Total Alkalinity | [_____] epm (meq/1) |
| Noncarbonate Hardness | [_____] epm (meq/1) |
| Total Hardness | [_____] epm (meq/1) |
| Dissolved Solids | [_____] ppm (mg/1) |
| Fluorine | [_____] ppm (mg/1) |
| Conductivity | [_____] micro-mho/cm |

2.17.2 Boiler Water Limits

**********
**NOTE: The material contained within the first set of brackets will be used for steam boilers. The material contained within the second set of brackets will be used for hot water boilers.**
**********

Consult the boiler manufacturer for the determination of the boiler water chemical composition limits. The boiler water limits are as follows unless dictated differently by the boiler manufacturer's recommendations: [

| | |
|---|---|
| Causticity | 20-200 ppm |
| Total Alkalinity (CACO3) | 900-1200 ppm |
| Phosphate | 30-60 ppm |
| Tanin | Medium |
| Dissolved Solids | 3000-5000 ppm |
| Suspended Solids | 300 ppm Max |
| Sodium Sulfite | 20-40 ppm Max |
| Silica | Less than 150 ppm |
| Dissolved Oxygen | Less than 7 ppm |
| Iron | 10 ppm |
| pH (Condensate) | 7 - 8 |

][

| | |
|---|---|
| Sodium Sulfite | 20-40 ppm |
| Hardness | Less than 2 ppm |
| pH | 9.3 - 9.9 |

]

2.17.3 Water Softening System

**********

**NOTE: The makeup water analysis and the boiler manufacturer's recommended feed water conditions will be used to determine the need for a water softener. UFC 3-230-03 contains general guidance for the selection.**

**********

Provide water softening system as specified in Section 22 31 00 WATER SOFTENERS, CATION-EXCHANGE (SODIUM CYCLE).

2.17.4 Chemical Feed Pumps

**********

**NOTE: The required maximum pump flow rate will be shown on the drawings. The flow rate will depend upon the makeup water flow rate and the chemical composition of the makeup water. A water treatment company should be consulted for determining the proper maximum pump flow rate.**

**********

Provide one pump for each chemical feed tank. Provide positive displacement diaphragm type chemical feed pumps. The capacity of the

pumps must be adjustable from 0 to 100 percent while in operation. The discharge pressure of the pumps must not be less than 1.5 times the pressure at the point of connection. Provide pumps with a pressure relief valve and a check valve mounted in the pump discharge.

2.17.5 Tanks

**********

**NOTE: A water treatment company will be consulted to determine the number of tanks required. The number will depend on the size of the boiler, makeup water flow rate, and makeup water composition. A water line will be provided near the tanks for the mixing of chemicals.**

**********

Construct tanks of [high density polyethylene] [stainless steel] with a hinged cover. Provide tanks with sufficient capacity to require recharging only once per 7 days during normal operation. Incude a level indicating device with each tank. Provide an electric agitator for each tank.

2.17.6 Injection Assemblies

Provide an injection assembly at each chemical injection point located along the boiler piping as indicated. Construct the injection assemblies of stainless steel. Extend the discharge of the assemblies to the centerline of the piping. Include a shutoff valve and check valve at the point of entrance into the water line with each assembly.

2.17.7 Water Meter

Provide water meter with an electric contacting register and remote accumulative counter. Install the meter within the makeup water line, as indicated.

2.17.8 Water Treatment Control Panel

**********

**NOTE: The MAN-OFF-AUTO switch should be deleted for continuously fed systems.**

**********

Provide a NEMA 12, single door, wall-mounted box conforming with NEMA 250 control panel. Construct the panel of [steel] [stainless steel] with a hinged door and lock. The panel must contain, as a minimum, the following functions identified with a laminated plastic nameplate:

a. Main power switch and indicating light

b. MAN-OFF-AUTO selector switch

c. Indicating lamp for blow down

d. Indicating lamp for each chemical feed pump

e. Indicating lamp for the water softener

2.17.9 Sequence of Operation

**********

**NOTE: Manually set flow rates should only be used when fluctuations in steam demand and makeup water are not expected. Typically, automatic blowdown will be economical for boilers with capacities greater than 2.9 MW 10,000,000 Btuh.**

**********

Base the flow rate of chemical addition upon [metering the makeup water.] [a manual setting.] Provide the boiler with [continuous blowdown.] [automatic blowdown based upon conductivity or boiler load.] Determine the required rate of chemical feed and boiler blowdown by the water treatment company.

2.17.10 Chemical Shot Feeder

Provide a shot feeder as indicated. Base size and capacity of feeder upon local requirements and water analysis. Furnish the feeder with an air vent, gauge glass, funnel, valves, fittings, and piping.

2.17.11 Chemical Piping

**********

**NOTE: If steel piping is selected, an interior coating may be required depending upon the chemicals used.**

**********

Construct piping and fittings of [schedule 80 PVC] [steel] [stainless steel].

2.17.12 Test Kits

Provide one test kit of each type required to determine the water quality as outlined within the operation and maintenance manuals.

2.17.13 Glycol Feed System

Design the Glycol feed system to automatically maintain the desired glycol content of the closed water recirculation system(s). Each system must consist of the following components:

2.17.13.1 Supply Tank and Stand

Include a 200 liter50 gallon cross lined polyethylene tank and steel support stand. Provide tank with a cover and bottom outlet fitting for pump suction. Equip the tank stand with a pump mounting platform and support for the control panel and level switch.

2.17.13.2 Glycol Pump

Rotary gear type of bronze construction with a capacity of 0.114 liter/sec 1.8 gpm at 275.8 kPa40 psi. Provide pump with a 0.35 kw1/3 horsepower, 1/115V/60hz motor and internal pressure relief. Provide the pump with a discharge check valve and shutoff valve.

2.17.13.3 Pressure Switch

Provide pressure switch that is adjustable over the range of 20.7 - 103.4 kPa3 - 15 psi with a 42.4 kPa6 psi differential and have contacts rated for 115V.

2.17.13.4 Level Switch

Equipped with N/O and N/C contacts to activate upon sensing a low level condition.

2.17.13.5 Control Panel

Install the control panel in a NEMA 1 enclosure with terminal strip and include a red low level alarm light, low level alarm bell and silence button, full voltage motor starter for the glycol pump, and a Hand-Off-Auto selector switch.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with details of the work, verify dimensions in the field, and advise the Contracting Officer of any discrepancy before performing any work or ordering any materials.

3.2 ERECTION OF BOILER AND AUXILIARY EQUIPMENT

**********

**NOTE: Consult boiler manufacturers for foundation requirements. Delete the requirement for packing the joint between the boiler and floor with nonasbestos rope, if not required. This packing is typically not required for smaller units.**

**********

Install boiler and auxiliary equipment in accordance with manufacturer's written instructions. Make proper provision for expansion and contraction between boiler foundation and floor. Pack this joint with suitable nonasbestos rope and fill with suitable compound that will not become soft at a temperature of 40 degrees C 100 degrees F. Support boilers and firing equipment from the foundations by structural steel completely independent of all brickwork. Boiler supports must permit free expansion and contraction of each portion of the boiler without placing undue stress on any part of the boiler or setting. Boiler breeching must be as indicated with full provision for expansion and contraction between all interconnected components.

3.3 PIPING INSTALLATION

Unless otherwise specified, provide nonboiler external pipe and fittings conforming to the requirements of ASME B31.1. Cut pipe accurately to suit field conditions, install without springing or forcing, and properly clearing windows, doors, and other openings. Cutting or other weakening of the building structure to facilitate piping installation will not be permitted. Provide pipes that are free of burrs, oil, grease and other foreign material and install to permit free expansion and contraction without damaging the building structure, pipe, pipe joints, or pipe supports. Make changes in direction with fittings, except that bending of

pipe 100 mm 4 inches and smaller will be permitted provided a pipe bender is used and wide sweep bends are formed. The centerline radius of bends must not be less than 6 diameters of the pipe. Bent pipe showing kinks, wrinkles, flattening, or other malformations will not be accepted. Carry vent pipes through the roof as directed and flash properly. Unless otherwise indicated, pitch horizontal supply mains down in the direction of flow with a grade of no less than 0.2 percent 1 inch in 40 feet. Properly cap or plug open ends of pipelines and equipment during installation to keep dirt or other foreign materials out of the systems. Pipe not otherwise specified must be uncoated. Unless otherwise specified or shown, make final connections to equipment with malleable-iron unions for steel pipe 65 mm 2-1/2 inches or less in diameter and with flanges for pipe 80 mm 3 inches or more in diameter. Provide brass or bronze unions for copper pipe or tubing. Use reducing fittings for changes in pipe sizes. In horizontal hot water lines, use eccentric type reducing fittings to maintain the top of the lines at the same level to prevent air binding.

### 3.3.1 Hot Water Piping and Fittings

Pipe must be black steel or copper tubing. Fittings for steel piping must be black malleable iron or cast iron to suit piping. Fittings adjacent to valves must suit valve material. Grooved mechanical fittings will not be allowed for water temperatures above 110 degrees C 230 degrees F.

### 3.3.2 Vent Piping and Fittings

Provide black steel vent piping. Fittings must be black malleable iron or cast iron to suit piping.

### 3.3.3 Gauge Piping

Piping must be copper tubing.

### 3.3.4 Steam Piping and Fittings

Provide black steel piping. Provide black, malleable iron, cast iron or steel fittings. Fittings adjacent to valves must suit valves specified. Grooved mechanical fittings will not be allowed for steam piping.

### 3.3.5 Condensate Return Pipe and Fittings

Provide black steel piping. Provide malleable iron, cast iron, or steel fittings. Grooved mechanical fittings will not be allowed for condensate piping.

### 3.3.6 Joints

Provide threaded, grooved, flanged or welded joints between sections of steel pipe and between steel pipe and fittings as indicated or specified. Except as otherwise specified, fittings 25 mm 1 inch and smaller must be threaded; fittings 32 mm 1-1/4 inches and up to but not including 80 mm 3 inches must be either threaded, grooved, or welded; and fittings 80 mm 3 inches and larger must be either flanged, grooved, or welded. Weld pipe and fittings 32 mm 1-1/4 inches and larger installed in inaccessible conduit or trenches beneath concrete floor slabs. Make connections to equipment with black malleable-iron unions for pipe 65 mm 2-1/2 inches or smaller in diameter and with flanges for pipe 80 mm 3 inchesor larger in diameter. Provide flared, soldered, or brazed joints between sections of

copper tubing or pipe.

3.3.6.1 Threaded Joints

Make threaded joints with tapered threads properly cut and make perfectly tight with a stiff mixture of graphite and oil or with polytetrafluoroethylene tape applied to the male threads only and in no case to the fittings.

3.3.6.2 Welded Joints

Weld joints in accordance with paragraph GENERAL REQUIREMENTS unless otherwise specified. Make changes in direction of piping with welding fittings only; mitering or notching pipe to form elbows and tees or other similar type construction will not be permitted. Branch connections may be made with either welding tees or forged branch outlet fittings, either being acceptable without size limitation. Branch outlet fittings, where used, must be forged, flared for improved flow characteristics where attached to the run, reinforced against external strains, and designed to withstand full pipe bursting strength. Assemble socket weld joints so that the space between the end of the pipe and the bottom of the socket is no less than 1.5 mm 1/16 inch and no more than 3 mm 1/8 inch.

3.3.6.3 Grooved Mechanical Joints

Grooved mechanical joints may be provided for hot water systems in lieu of unions, welded, flanged, or screwed piping connections in low temperature hot water systems where the temperature of the circulating medium does not exceed 110 degrees C 230 degrees F. Prepare grooves according to the coupling manufacturer's instructions. Use pipe and groove dimensions in compliance with the tolerances specified by the coupling manufacturer. Measure the diameter of grooves made in the field using a "go/no-go" gauge, vernier or dial caliper, narrow-land micrometer or other method specifically approved by the coupling manufacturer for the intended application. Measure and record groove width and dimension of groove from end of pipe for each change in grooving tool setup to verify compliance with coupling manufacturer's tolerances. Do not use grooved joints in concealed locations. Mechanical joints must use rigid mechanical pipe couplings, except at equipment connections. At equipment connections, flexible couplings may be used. Provide bolted type coupling for use with grooved end pipes, fittings, valves, and strainers. Provide self-centering couplings that engage in a watertight couple.

3.3.6.4 Flared and Brazed Copper Pipe and Tubing

Cut tubing square, and remove burrs. Clean both inside of fittings and outside of tubing thoroughly with sand cloth or steel wire brush before brazing. Annealing of fittings and hard-drawn tubing must not occur when making connections. Install in accordance with the manufacturer's recommendations. Mitering of joints for elbows and notching of straight runs of pipe for tees will not be permitted. Make brazed joints in conformance with AWS B2.2/B2.2M and CDA A4015 with flux. Copper-to-copper joints must include the use of copper-phosphorous or copper-phosphorous-silver brazing metal without flux. Brazing of dissimilar metals (copper to bronze or brass) must include the use of flux with either a copper-phosphorous, copper-phosphorous-silver or a silver brazing filler metal. Joints for flared fittings must be of the compression pattern. Provide swing joints or offsets in all branch connections, mains, and risers to provide for expansion and contraction

forces without undue stress to the fittings or to short lengths of pipe or tubing. Provide flared or brazed copper tubing to pipe adapters where necessary for joining threaded pipe to copper tubing.

3.3.6.5 Soldered Joints

Make soldered joints with flux and are only acceptable for lines 50 mm 2 inches and smaller. Provide soldered joints conforming to ASME B31.5 and CDA A4015.

3.3.6.6 Copper Tube Extracted Joint

An extruded mechanical tee joint may be made in copper tube. Produce joint with an appropriate tool by drilling a pilot hole and drawing out the tube surface to form a collar having a minimum height of three times the thickness of the tube wall. To prevent the branch tube from being inserted beyond the depth of the extracted joint, provide dimpled depth stops. Notch the branch tube for proper penetration into fitting to assure a free flow joint. Braze extracted joints using a copper phosphorous classification brazing filler metal. Soldered joints will not be permitted.

3.3.7 Flanges and Unions

Provide faced true flanges with 1.6 mm 1/16 inch thick gaskets, and make square and tight. Where steel flanges mate with cast-iron flanged fittings, valves, or equipment, provide flanges with flat faces and full face gaskets. Provide union or flange joints in each line immediately preceding the connection to each piece of equipment or material requiring maintenance such as coils, pumps, control valves, and other similar items. Provide dielectric pipe unions between ferrous and nonferrous piping to prevent galvanic corrosion. Use dielectric unions with metal connections on both ends. The ends must be threaded, flanged, or brazed to match adjacent piping. Separate the metal parts of the union so that the electrical current is below 1 percent of the galvanic current which would exist upon metal-to-metal contact. Install gaskets, flanges, and unions in accordance with manufacturer's recommendations.

3.3.8 Branch Connections

**********
**NOTE: Select the appropriate type of branch connections and delete those which are not required.**
**********

3.3.8.1 Branch Connections for Hot Water Systems

Pitch branches from the main up or down as shown to prevent air entrapment. Connections must ensure unrestricted circulation, eliminate air pockets, and permit complete drainage of the system. Pitch branches with a grade of no less than 8 mm in 1 m 1 inch in 10 feet. When indicated, install special flow fittings on the mains to bypass portions of the water through each radiator. Use special flow fittings that are standard catalog products and install as recommended by the manufacturer.

3.3.8.2 Branch Connections for Steam Systems

Take branches from the supply mains at an angle of 45 degrees above the horizontal, unless otherwise indicated. Take branches from return mains

from the top or sides, unless indicated otherwise. Pitch branches up from the mains toward the undripped risers or radiator connections with a grade of no less than 8 mm in 1 m 1 inch in 10 feet. Connections must ensure unrestricted circulation, eliminate air pockets, and permit the complete drainage of the system.

### 3.3.9 Steam Connections to Equipment

**********
**NOTE: Delete this paragraph if steam connections are not required.**
**********

Provide steam supply and return connections as shown. Make connections with malleable-iron unions or with steel flanges, to match equipment. Install valves and traps in accordance with the manufacturer's recommendations. The size of the supply and return pipes to each piece of equipment must not be smaller than the outlets on the equipment.

### 3.3.10 Steam Risers

**********
**NOTE: Delete this paragraph if steam risers are not required.**
**********

The location of risers is approximate. The exact locations of the risers must be approved. Terminate downfeed risers in a dirt pocket and drip through a trap to the return line.

### 3.3.11 Air Vents for Steam Systems

**********
**NOTE: Delete this paragraph if a steam system is not utilized.**
**********

Install automatic balanced pressure thermostatic air vents at the ends of the steam lines and where shown on the drawings. Use vents that are rated for 862 kPa 125 psi steam service. Route the outlet of the vent to a point designated by the Contracting Officer's Representative. Provide inlet line with a gate valve or ball valve.

### 3.3.12 Flared, Brazed, and Soldered Copper Pipe and Tubing

Provide flared, brazed, or soldered copper tubing. Cut tubing square, and remove burrs. Clean both inside of fittings and outside of tubing thoroughly with sand cloth or steel wire brush before brazing. Annealing of fittings and hard-drawn tubing must not occur when making connections. Install in accordance with the manufacturer's recommendations. Mitering of joints for elbows and notching of straight runs of pipe for tees will not be permitted. Joints for flared fittings must be of the compression pattern. Provide swing joints or offsets on branch connections, mains, and risers to provide for expansion and contraction forces without undue stress to the fittings or to short lengths of pipe or tubing. Provide pipe adapters where necessary for joining threaded pipe to copper tubing. Make brazed joints in conformance with CDA A4015. Copper-to-copper joints must include the use of copper-phosphorous or copper-phosphorous-silver brazing metal without flux. Brazing of dissimilar metals (copper to

bronze or brass) must include the use of flux with either a copper-phosphorous, copper-phosphorous-silver, or a silver brazing filler metal. Make soldered joints with flux and are only acceptable for lines 50 mm 2 inches or smaller. Provide soldered joints conforming to ASME B31.5 and in accordance with CDA A4015.

3.3.13 Copper Tube Extracted Joint

An extracted mechanical tee joint may be made in copper tube. Produce joint with an appropriate tool by drilling a pilot hole and drawing out the tube surface to form a collar having a minimum height of three times the thickness of the tube wall. To prevent the branch tube from being inserted beyond the depth of the extracted joint, provide dimpled depth stops. Notch the branch tube for proper penetration into fitting to assure a free flow joint. Braze extracted joints using a copper phosphorous classification brazing filler metal. Soldered joints will not be permitted.

3.3.14 Supports

Fabricate hangers used to support piping 50 mm 2 inches and larger to permit adequate adjustment after erection while still supporting the load. Install pipe guides and anchors to keep pipes in accurate alignment, to direct the expansion movement, and to prevent buckling, swaying, and undue strain. Support piping subjected to vertical movement when operating temperatures exceed ambient temperatures by variable spring hangers and supports or by constant support hangers. Do not use formed or bent threaded rods for support. Do not attach supports to the underside of concrete filled floors or concrete roof decks unless approved by the Contracting Officer.

3.3.14.1 Seismic Requirements for Supports and Structural Bracing

**********

**NOTE: Provide seismic requirements, if a Government designer (either Corps Office of A/E) is the Engineer of Record, and show on the drawings. Delete the bracketed phrase if no seismic requirements are provided. Section 13 48 73, properly edited, must be included in the contract documents.**

**********

Support and brace piping and attached valves to resist seismic loads as specified in Section 13 48 73 SEISMIC CONTROL FOR MISCELLANEOUS EQUIPMENT [and ][as shown on the drawings]. Provide structural steel required for reinforcement to properly support piping, headers, and equipment, but not shown, in this section. Use material for supports as specified in Section 05 12 00 STRUCTURAL STEEL.

3.3.14.2 Pipe Hangers, Inserts, and Supports

**********

**NOTE: Details of pipe supports in trenches will be shown on the drawings. Mechanical and electrical layout drawings and specifications for ceiling suspensions should contain notes indicating that hanger loads between panel points in excess of 225 N 50 pounds must have the excess hanger loads**

**suspended from panel points.**
**********

Provide pipe hangers, inserts, and supports conforming to MSS SP-58, except as modified herein.

3.3.14.2.1 Types 5, 12, and 26

Use of Types 5, 12, and 26 is prohibited.

3.3.14.2.2 Type 3

Do not use Type 3 on insulated pipe which has a vapor barrier. Type 3 may be used on insulated pipe that does not have a vapor barrier if clamped directly to the pipe, if the clamp bottom does not extend through the insulation, and if the top clamp attachment does not contact the insulation during pipe movement.

3.3.14.2.3 Type 18

Secure Type 18 inserts to concrete forms before concrete is placed. Continuous inserts which allow more adjustment may be used if they otherwise meet the requirements for Type 18 inserts.

3.3.14.2.4 Type 19 and 23 C-Clamps

Torque Type 19 and 23 C-clamps in accordance with MSS SP-58 and have both locknuts and retaining devices furnished by the manufacturer. Field fabricated C-clamp bodies or retaining devices are not acceptable.

3.3.14.2.5 Type 20 Attachments

Furnish Type 20 attachments used on angles and channels with an added malleable-iron heel plate or adapter.

3.3.14.2.6 Type 24

Type 24 may be used only on trapeze hanger systems or on fabricated frames.

3.3.14.2.7 Horizontal Pipe Supports

Space horizontal pipe supports as specified in MSS SP-58 and do not install a support over 300 mm 1 foot from the pipe fitting joint at each change in direction of the piping. Do not space pipe supports over 1500 mm 5 feet apart at valves.

3.3.14.2.8 Vertical Pipe Support

Support vertical pipe at each floor, except at slab-on-grade, and at intervals of no more than 4500 mm 15 feet, no more than 2400 mm 8 feet from end of risers, and at vent terminations.

3.3.14.2.9 Type 35 Guides

Provide Type 35 guides using steel, reinforced polytetrafluoroethylene (PTFE) or graphite slides where required to allow longitudinal pipe movement. Provide lateral restraints as required. Provide slide materials suitable for the system operating temperatures, atmospheric conditions, and bearing loads encountered.

a. Where steel slides do not require provisions for restraint of lateral movement, an alternate guide method may be used. On piping 100 mm 4 inches and larger, a Type 39 saddle may be welded to the pipe and freely rested on a steel plate. On piping under 100 mm 4 inches, a Type 40 protection shield may be attached to the pipe or insulation and freely rested on a steel slide plate.

b. Where there are high system temperatures and welding to piping is not desirable, include a pipe cradle welded to the guide structure and strapped securely to the pipe. Separate the pipe from the slide material by at least 100 mm 4 inches or by an amount adequate for the insulation, whichever is greater.

3.3.14.2.10 Horizontal Insulated Pipe

Except for Type 3, pipe hangers on horizontal insulated pipe must be the size of the outside diameter of the insulation.

3.3.14.2.11 Piping in Trenches

Support piping in trenches as indicated.

3.3.14.2.12 Structural Steel Attachments

Provide structural steel attachments and brackets required to support piping, headers, and equipment, but not shown, under this section. Provide material and installation as specified under Section 05 12 00 STRUCTURAL STEEL. Do not exceed 22 kg 50 pounds for pipe hanger loads suspended from steel joist between panel points. Suspend loads exceeding 22 kg 50 pounds from panel points.

3.3.14.3 Multiple Pipe Runs

In the support of multiple pipe runs on a common base member, use a clip or clamp where each pipe crosses the base support member. Spacing of the base support member must not exceed the hanger and support spacing required for any individual pipe in the multiple pipe run. Attach the clips or clamps rigidly to the common base member. Provide a clearance of 3 mm 1/8 inch between the pipe insulation and the clip or clamp for piping which may be subjected to thermal expansion.

3.3.15 Anchors

**********

**NOTE: Anchors will be coordinated with seismic bracing. Seismic bracing should not interfere with the thermal expansion design.**

**********

Provide anchors where necessary to localize expansion or to prevent undue strain on piping. Provide anchors consisting of heavy steel collars with lugs and bolts for clamping and attaching anchor braces, unless otherwise indicated. Install anchor braces in the most effective manner to secure the desired results, using turnbuckles where required. Do not attach supports, anchors, or stays where they will injure the structure or adjacent construction during installation or by the weight of expansion of the pipeline.

### 3.3.16 Valves

Install valves where indicated, specified, and required for functioning and servicing of the systems. Ensure valves are safely accessible. Install swing check valves upright in horizontal lines and in vertical lines only when flow is in the upward direction. Install gate and globe valves with stems horizontal or above. Disassemble valves to be brazed prior to brazing and remove all packing. After brazing, allow the valves to cool before reassembling.

### 3.3.17 Pipe Sleeves

Provide pipe passing through concrete or masonry walls or concrete floors or roofs with pipe sleeves fitted into place at the time of construction. Install a waterproofing clamping flange as indicated where membranes are involved. Do not install sleeves in structural members except where indicated or approved. Provide rectangular and square openings as detailed. Extend each sleeve through its respective wall, floor, or roof. Cut sleeves through walls flush with wall surface. Sleeves through floors mut [be cut flush with floor surface] [extend above top surface of floor a sufficient distance to allow proper flashing or finishing]. Extend sleeves through roofs above the top surface of roof at least 150 mm 6 inches for proper flashing or finishing. Unless otherwise indicated, size sleeves to provide a minimum clearance of 6 mm 1/4 inch between bare pipe and sleeves or between jacket over insulation and sleeves. Use galvanized steel pipe or cast-iron pipe sleeves in waterproofing membrane floors, bearing walls, and wet areas. Sleeves in nonbearing walls, floors, or ceilings may be galvanized steel pipe, cast-iron pipe, or galvanized sheet metal with lock-type longitudinal seam. Except in pipe chases or interior walls, seal the annular space between pipe and sleeve or between jacket over insulation and sleeve in nonfire rated walls as indicated and specified in Section 07 92 00 JOINT SEALANTS. Provide metal jackets over insulation passing through exterior walls, firewalls, fire partitions, floors, or roofs.

a. Metal jackets must not be thinner than 0.1524 mm 0.006 inch thick aluminum, if corrugated, and 0.4 mm 0.016 inch thick aluminum, if smooth.

b. Secure metal jackets with aluminum or stainless steel bands not less than 9 mm 3/8 inch wide and not more than 200 mm 8 inches apart. When penetrating roofs and before fitting the metal jacket into place, run a 13 mm 1/2 inch wide strip of sealant vertically along the inside of the longitudinal joint of the metal jacket from a point below the backup material to a minimum height of 1000 mm 36 inches above the roof. If the pipe turns from vertical to horizontal, run the sealant strip to a point just beyond the first elbow. When penetrating waterproofing membrane for floors, extend the metal jacket from a point below the back-up material to a minimum distance of 50 mm 2 inches above the flashing. For other areas, extend the metal jacket from a point below the backup material to a point 300 mm 12 inches above material to a minimum distance of 50 mm 2 inches above the flashing. For other areas, extend the metal jacket from a point below the backup material to a point 300 mm 12 inches above the floor; when passing through walls above grade, extend the jacket at least 100 mm 4 inches beyond each side of the wall.

3.3.17.1 Pipes Passing Through Waterproofing Membranes

In addition to the pipe sleeves referred to above, provide pipes passing through waterproofing membranes with a 1.6 mm 4 pound lead flashing or a 0.55 mm 16 ounce copper flashing, each within an integral skirt or flange. Suitably form flashing, and extend the skirt or flange no less than 200 mm 8 inches from the pipe and set over the membrane in a troweled coating of bituminous cement. Extend the flashing above the roof or floor a minimum of 250 mm 10 inches. Seal the annular space between the flashing and the bare pipe or between the flashing and the metal-jacket-covered insulation as indicated. Pipes up to and including 250 mm 10 inches in diameter which pass through waterproofing membrane may be installed through a cast-iron sleeve with caulking recess, anchor lugs, flashing clamp device, and pressure ring with brass bolts. Clamp waterproofing membrane into place and place sealant in the caulking recess.

3.3.17.2 Optional Modular Mechanical Sealing Assembly

At the option of the Contractor, a modular mechanical type sealing assembly may be installed in the annular space between the sleeve and conduit or pipe in lieu of a waterproofing clamping flange and caulking and sealing specified above. Provide seals with interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe/conduit and sleeve with corrosion-protected carbon steel bolts, nuts, and pressure plates. Assemble the links loosely with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and each nut. After the seal assembly is properly positioned in the sleeve, tighten the bolt to cause the rubber sealing elements to expand and provide a watertight seal between the pipe/conduit and the sleeve. Size each seal assembly as recommended by the manufacturer to fit the pipe/conduit and sleeve involved.

3.3.17.3 Optional Counterflashing

As alternates to caulking and sealing the annular space between the pipe and flashing or metal-jacket-covered insulation and flashing, counterflashing may consist of standard roof coupling for threaded pipe up to 150 mm 6 inches in diameter, lead flashing sleeve for dry vents with the sleeve turned down into the pipe to form a waterproof joint, or a tack-welded or banded-metal rain shield around the pipe, sealed as indicated.

3.3.17.4 Fire Seal

Where pipes pass through firewalls, fire partitions, or floors, provide a fire seal as specified in Section 07 84 00 FIRESTOPPING.

3.3.18 Balancing Valves

Install balancing valves as indicated.

3.3.19 Thermometer Wells

Provide a thermometer well in each return line for each circuit in multicircuit systems.

3.3.20 Air Vents

Install air vents in piping at all system high points. Keep the vent open

until water rises in the tank or pipe to a predetermined level at which time it must close tight. Run an overflow pipe from the vent to a point designated by the Contracting Officer's representative. Provide inlet to the air vent with a gate valve or ball valve.

### 3.3.21 Escutcheons

Provide escutcheons at all finished surfaces where exposed piping, bare or insulated, passes through floors, walls, or ceilings except in boiler, utility, or equipment rooms. Fasten chromium-plated iron or chromium-plated brass, either one-piece or split pattern, escutcheons securely to pipe or pipe covering and hold in place by internal spring tension or setscrews.

### 3.3.22 Drains

Install a drain connection with a 25 mm 1 inch gate valve or 19 mm 3/4 inch hose bib at the lowest point in the return main near the boiler. In addition, install threaded drain connections with threaded cap or plug on the heat exchanger coil on each unit heater or unit ventilator and wherever required for thorough draining of the system.

### 3.3.23 Strainer Blow-Down Piping

Fit strainer blow-down connections with a black steel blow-down pipeline routed to an accessible location and provided with a blow-down valve.

### 3.3.24 Direct Venting for Combustion Intake Air and Exhaust Air

**********

**NOTE: Delete this paragraph if condensing boilers are not used.**

**********

Install intake air and exhaust vents in accordance with NFPA 54 and boiler manufacturer's recommendations. Slope exhaust vent 20.8 mm/m 1/4 inch/ft toward the boiler's flue gas condensate collection point.

## 3.4 GAS FUEL SYSTEM

Provide gas piping, fittings, valves, regulators, tests, cleaning, and adjustments in accordance with the Section 23 11 20 FACILITY GAS PIPING. Submit proposed test schedules for the heating system and fuel system tests, at least 2 weeks prior to the start of related testing. Comply with NFPA 54 unless otherwise specified. Provide burners, pilots, and all accessories that are listed in UL FLAMMABLE & COMBUSTIBLE. Provide fuel system with a gas tight, manually operated, UL listed stop valve at the gas-supply connections, a gas strainer, a pressure regulator, pressure gauges, a burner-control valve, a safety shutoff valve suitable for size of burner and sequence of operation, and other components required for safe, efficient, and reliable operation as specified. Provide approved permanent and ready facilities to permit periodic valve leakage tests on the safety shutoff valve or valves.

## 3.5 FUEL OIL SYSTEM

Install fuel oil system in accordance with NFPA 31, unless otherwise indicated.

### 3.5.1 Piping and Storage Tank

Istall fuel oil piping and storage tanks in accordance with Section 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS, unless indicated otherwise.

### 3.5.2 Fuel-Oil Storage Tank Heating-Coil Piping

Install supply and return piping and fittings for the heating coil in accordance with paragraph PIPING INSTALLATION. Provide [hot water] [steam] supply line to the heating coil with an automatic temperature-control valve, a strainer and a three-valve bypass. Provide return line from the coil with a [check valve] [steam trap] and a block valve.

### 3.5.3 Automatic Safety Shutoff Valve

Equip oil supply line to each oil burner with an automatically operated valve designed to shut off the oil supply in case of fire in the immediate vicinity of the burner. Provide thermoelectrically actuated or thermomechanically actuated type valve and locate immediately downstream of the manual shutoff valve at the day tank inside of the building. If a day tank is not used, locate the automatic safety valve immediately downstream of the building shutoff devices where oil supply line enters the building. Locate a thermoelectrical or thermomechanical detection device over the oil burner to activate the valve. A fire shutoff valve may be combined with other automatic shutoff devices if listed in UL FLAMMABLE & COMBUSTIBLE.

### 3.5.4 Earthwork

Perform excavation and backfilling for tanks and piping as specified in Section 31 00 00 EARTHWORK.

## 3.6 RADIANT FLOOR HEATING SYSTEM

Install radiant floor heating system in accordance with HI-004, unless otherwise indicated by the tubing manufacturer's installation instructions. During the installation, plug all tubing on each end to prevent foreign materials from entering the tubing. Check all tubing for abrasions prior to installation. Tubing with excessive abrasions that damage the oxygen barrier coating will not be acceptable. Tubing with any abrasion that is greater than 10 percent of the minimum wall thickness will not be acceptable. Install all tubing embedded or concealed by the floor without joints. The bending radius of the tubing must not exceed the values recommended by the tubing manufacturer. Install tubing in such a manner as to evenly distribute the heat across the floor. Do not place tubing near heat sensitive materials such as water closet seals. Install isolation valves on each side of each tubing manifold. The manifold and fittings must be accessible for maintenance. After the system is filled with water or glycol, vent all air from the system. After the system is allowed to stabilize at the operating temperatures of the heating fluid, vent the system again.

### 3.6.1 Concrete Slab construction

**********

**NOTE: Delete this paragraph if slab construction is not required. The type of installation under the slab should be coordinated with the architect and**

**structural engineer.**
**********

In areas where tubing must cross expansion joints, control joints, or other crack control measures, install the tubing below the joints. Fasten the tubing to the reinforcing steel in accordance with the tubing manufacturer's recommendations. Pressurize tubing prior to and during the concrete pour to ensure system integrity.

### 3.6.2 Wooden Floor Construction

**********
**NOTE: Delete this paragraph if a wooden floor construction is not required.**
**********

Fasten tubing to the wood subflooring in accordance with the drawings and the tubing manufacturer's recommendations. Attach the tubing to the flooring without causing abrasions on the tubing.

### 3.6.3 Penetrations to Fire Rated Assemblies

Where pipe pass through firewalls, fire partitions, or floors, provide a fire seal as specified in Section 07 84 00 FIRESTOPPING.

## 3.7 COLOR CODE MARKING AND FIELD PAINTING

**********
**NOTE: Designer will coordinate color code marking with Section 09 90 00. Color code marking for piping not listed in Table 1 of Section 09 90 00 will be added to the table.**
**********

Color code marking of piping must be as specified in Section 09 90 00 PAINTS AND COATINGS. Clean, prepare, and paint ferrous metal not specified to be coated at the factory as specified in Section 09 90 00 PAINTS AND COATINGS. Paint exposed pipe covering as specified in Section 09 90 00 PAINTS AND COATINGS. Do not paint aluminum sheath over insulation.

## 3.8 MANUFACTURER'S SERVICES

Provide the services of a manufacturer's representative who is experienced in the installation, adjustment, and operation of the equipment specified to supervise the installing, adjusting, and testing of the equipment.

## 3.9 TEST OF BACKFLOW PREVENTION ASSEMBLIES

Test backflow prevention assemblies in accordance with Section 22 00 00 PLUMBING, GENERAL PURPOSE.

## 3.10 HEATING SYSTEM TESTS

**********
**NOTE: Whenever possible, the testing of heating systems will be done under adverse winter conditions and low outside temperatures. The test data included will be modified as required to suit the**

**particular heating system.**

**Select a 4 hour hydrostatic test for radiant floor heating systems in accordance with HYI 400. All other systems should be tested for 2 hours.**

**********

Submit the Qualifications of the firms in charge of installation and testing as specified. Submit a statement from the firms proposed to prepare submittals and perform installation and testing, demonstrating successful completion of similar services of at least five projects of similar size or scope, at least 2 weeks prior to the submittal of any other item required by this section. Before any covering is installed on pipe or heating equipment, hydrostatically test and prove tight the entire heating system's piping, fittings, and terminal heating units at a pressure of 1.5 times the design working pressure, but no less than 689 kPa 100 psi. Submit proposed test procedures for the heating system tests and fuel system tests, at least 2 weeks prior to the start of related testing.

a. Before pressurizing system for test, blank off items or equipment (e.g., vessels, pumps, instruments, controls, relief valves) rated for pressures below the test pressure or replace with spool pieces.

b. Before balancing and final operating test, remove test blanks and spool pieces; and reconnect protected instruments and equipment. With equipment items protected, pressurize the system to test pressure. Hold pressure for a period of time sufficient to inspect all welds, joints, and connections for leaks, but no less than 2 hours. No loss of pressure will be allowed. Repair leaks and retest repaired joint.

c. Repair joints are not allowed under the floor for floor radiant heating systems. If a leak occurs in tubing located under the floor in radiant heating systems, replace the entire zone that is leaking. If any repair is made above the floor for floor radiant heating systems, provide access for the installed joint. Caulking of joints is not permitted.

d. Drain system and after instruments and equipment are reconnected, refill the system with service medium and maximum operating pressure applied. Hold the pressure while inspecting these joints and connections for leaks. Repair the leaks and retest the repaired joints.

Upon completion of hydrostatic tests and before acceptance of the installation, submit test reports for the heating system tests. Upon completion of testing complete with results, balance the heating system in accordance with Section 23 05 93 TESTING, ADJUSTING, AND BALANCING OF HVAC SYSTEMS and operating tests required to demonstrate satisfactory functional and operational efficiency. Cover a period of at least 24 hours for each system, and include, as a minimum, the following specific information in a report, together with conclusions as to the adequacy of the system:

a. Certification of balancing.

b. Time, date, and duration of test.

c. Outside and inside dry bulb temperatures.

d. [Temperature of hot water supply leaving boiler] [Steam pressure].

e. Temperature of [heating return water from system at] [condensate feed to] boiler inlet.

f. Quantity of water feed to boiler.

g. Boiler make, type, serial number, design pressure, and rated capacity.

h. Fuel burner make, model, and rated capacity; ammeter and voltmeter readings for burner motor.

i. [Circulating] [Condensate] [Vacuum] pump make, model, and rated capacity, and ammeter and voltmeter readings for pump motor during operation.

j. Flue-gas temperature at boiler outlet.

k. Percent carbon dioxide in flue-gas.

l. Grade or type and calorific value of fuel.

m. Draft at boiler flue-gas exit.

n. Draft or pressure in furnace.

o. Quantity of water circulated.

p. Quantity of fuel consumed.

q. Stack emission pollutants concentration.

Read indicating instruments at half-hour intervals unless otherwise directed. Furnish all instruments, equipment, and personnel required for the tests and balancing. Obtain necessary natural gas, water and electricity as specified in the [SPECIAL CONTRACT REQUIREMENTS][Section 01 50 00 TEMPORARY CONSTRUCTION FACILITIES AND CONTROLS] Provide necessary quantities of propane gas or No. [_____] fuel oil when propane gas or fuel oil is require for testing. Demonstrate that fuel burners and combustion and safety controls meet the requirements of [ASME CSD-1] [ ANSI Z21.13/CSA 4.9] [NFPA 85]

### 3.10.1 Water Treatment Testing

Analyze the boiler water [prior to the acceptance of the facility] [a minimum of once a month for a period of 1 year] by the water treatment company. Submit a water quality test report identifying the chemical composition of the boiler water. Include a comparison of the condition of the boiler water with the manufacturer's recommended conditions. Document any required corrective action within the report. Identify the condition of the boiler at the completion of 1 year of service. Include a comparison of the condition of the boiler with the manufacturer's recommended operating conditions. Include the following information recorded in accordance with ASTM D596 in the analysis.

| | |
|---|---|
| Date of Sample | [_____] |
| Temperature | [_____] degrees C degrees F |
| Silica (SiO2) | [_____] ppm (mg/1) |
| Insoluble | [_____] ppm (mg/1) |
| Iron and Aluminum Oxides | [_____] ppm (mg/1) |
| Calcium (Ca) | [_____] ppm (mg/1) |
| Magnesium (Mg) | [_____] ppm (mg/1) |
| Sodium and Potassium (Na and K) | [_____] ppm (mg/1) |
| Carbonate (HCO3) | [_____] ppm (mg/1) |
| Sulfate (SO4) | [_____] ppm (mg/1) |
| Chloride (C1) | [_____] ppm (mg/1) |
| Nitrate (NO3) | [_____] ppm (mg/1) |
| Turbidity | [_____] ntu |
| pH | [_____] |
| Residual Chlorine | [_____] ppm (mg/1) |
| Total Alkalinity | [_____] epm (meq/1) |
| Noncarbonate Hardness | [_____] epm (meq/1) |
| Total Hardness | [_____] epm (meq/1) |
| Dissolved Solids | [_____] ppm (mg/1) |
| Fluorine | [_____] ppm (mg/1) |
| Conductivity | [_____] micro-mho/cm |

If the boiler water is not in conformance with the boiler manufacturer's recommendations, the water treatment company must take corrective action.

3.10.2 Boiler/Piping Test

**********

**NOTE: If a steam boiler is not used, delete the reference to condensate piping.**

**********

At the conclusion of the 1 year period, inspect the boiler and condensate piping for problems due to corrosion and scale. If the boiler is found

not to conform to the manufacturer's recommendations, and the water treatment company recommendations have been followed, the water treatment company must provide all chemicals and labor for cleaning or repairing the equipment as required by the manufacturer's recommendations. If corrosion is found within the condensate piping, make proper repairs.

## 3.11 CLEANING

### 3.11.1 Boilers and Piping

After the hydrostatic tests have been made and before the system is balanced and operating tests are performed, thoroughly clean the boilers and piping by filling the system with a solution consisting of either 0.5 kg 1 pound of caustic soda or 0.5 kg 1 pound of trisodium phosphate per 190 L 50 gallons of water. Observe proper safety precautions in the handling and use of these chemicals. Heat the water to approximately 65 degrees C 150 degrees F and circulate the solution in the system for a period of 48 hours. Then drain the system and thoroughly flush out with fresh water. Thoroughly clean strainers and valves. Prior to operating tests, remove air from all water systems by operating the air vents.

### 3.11.2 Heating Units

Thoroughly clean inside space heating equipment, ducts, plenums, and casing of debris and blow free of small particles of rubbish and dust and then vacuum clean before installing outlet faces. Wipe equipment clean, with all traces of oil, dust, dirt, or paint spots removed. Provide temporary filters for fans that are operated during construction, and provide new filters after construction dirt has been removed from the building, and the ducts, plenum, casings, and other items specified have been vacuum cleaned. Perform and document that proper "Indoor Air Quality During Construction" procedures have been followed; provide documentation showing that after construction ends, and prior to occupancy, new filters were provided and installed. Maintain system in this clean condition until final acceptance. Lubricate bearings properly with oil or grease as recommended by the manufacturer. Tighten belts to proper tension. Adjust control valves and other miscellaneous equipment requiring adjustment to setting indicated or directed. Adjust fans to the speed indicated by the manufacturer to meet specified conditions.

## 3.12 FIELD TRAINING

**********

**NOTE: The number of hours required for giving instructions for operation and maintenance will depend on the complexity of the system specified. The blank will be filled with the appropriate number. When the system is to be installed at a location where experienced Government engineers are on duty, delete the entire paragraph.**

**********

Conduct a training course for the operating staff as designated by the Contracting Officer. The training period consists of a total of [_____] hours of normal working time and start after the system is functionally completed but prior to final acceptance tests.

a. Cover all of the items contained in the approved operation and maintenance manuals, as well as demonstrations of routine maintenance

operations and boiler safety devices, in the field instructions.

b. Submit system layout diagrams that show the layout of equipment, piping, and ductwork and typed condensed operation manuals explaining preventative maintenance procedures, methods of checking the system for normal, safe operation, and procedures for safely starting and stopping the system, framed under glass or laminated plastic, at least 2 weeks prior to the start of related testing. After approval, post these items where directed.

c. Submit [six] [_____] complete operation and maintenance instructions listing step-by-step procedures required for system startup, operation, shutdown, and routine maintenance, at least 2 weeks prior to field training. Include the manufacturer's name, model number, parts list, simplified wiring and control diagrams, troubleshooting guide, and recommended service organization (including address and telephone number) for each item of equipment. Each service organization must be capable of providing [4] [_____] hour onsite response to a service call on an emergency basis.

d. Notify the Contracting Officer at least 14 days prior to date of proposed conduction of the training course.

## 3.13 FUEL SYSTEM TESTS

Submit test reports for the fuel system tests, upon completion of testing complete with results.

### 3.13.1 Fuel Oil System Test

Test fuel oil system in accordance with Section 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS.

### 3.13.2 Gas System Test

Test gas fuel system accordance with the test procedures outlined in NFPA 54.

-- End of Section --