

SECTION 235233 - WATER-TUBE BOILERS

TIPS:

To view non-printing **Editor's Notes** that provide guidance for editing, click on Masterworks/Single-File Formatting/Toggle/Editor's Notes.

To read **detailed research, technical information about products and materials, and coordination checklists**, click on Masterworks/Supporting Information.

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes packaged, factory-fabricated and -assembled, gas-fired, finned water-tube boilers for generating hot water.
- B. Section includes packaged, **[factory-]** **[or]** **[field-]** assembled, water-tube boilers for generating **[hot water]** **[steam]**.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product, include the following:
 - 1. Construction details, material descriptions, dimensions, and weights of individual components, profiles, and finishes for boilers.
 - 2. Rated capacities, operating characteristics, and furnished specialties and accessories.
 - 3. Predicted boiler efficiency while operating at design capacity and at varying part loads with basis indicated.
 - 4. Predicted emissions levels while operating at design capacity and at varying part loads with basis indicated. Indicate operation that produces worst-case emissions.
 - 5. Technical data for refractory and insulation, including temperature rating, thermal performance, attachment, and arrangement.
 - 6. Calculations showing predicted surface temperature of boiler jacket with basis indicated.
 - 7. Force and moment capacity of each piping and flue connection.
 - 8. Dimensioned location of low, high, and normal water level, showing operating set point and each alarm set point.
 - 9. Temperature and pressure rating, size, and materials of construction for boiler trim components, including piping, fittings, flanges, unions, and valves. Provide valve manufacturer's product data for each valve furnished. For safety valves, include trip and reset settings and flow capacity.

10. Manufacturer's product data showing size, scale range, and accuracy of thermometers and pressure gages.
11. Pressure rating, size, and materials of construction for boiler fuel train components, including piping, fittings, flanges, unions, switches, and valves. Provide manufacturer's product data for each valve and switch furnished.
12. Detailed information of controls, including product data with technical performance, operating characteristics, and sequence of operation.
13. Product data for each motor, including performance, operating characteristics, and materials of construction.

B. LEED Submittals:

1. Include supporting data to satisfy requirements of Project LEED credits.
2. Organize and identify standalone, supporting data for each LEED credit.
3. Project LEED credits applicable to boilers include:
 - a. Prerequisite EA 2.
 - b. **<Insert applicable LEED Energy and Atmosphere prerequisites and credits>.**

C. Shop Drawings: For boilers, boiler trim, and accessories.

1. Include plans, elevations, sections, and **[mounting]** **[attachment]** details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Design calculations and base details, signed and sealed by a qualified professional engineer.
 - a. Design Calculations: Calculate requirements for selecting **[vibration isolators and]** seismic restraints and for designing bases.
 - b. Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
4. Include diagrams for power, signal, and control wiring. Differentiate between factory and field installation.
5. Include piping diagrams of factory-furnished piping that indicate size and each piping component.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan and elevation views, drawn to **<Insert scale>** scale, indicating equipment manufacturers' service clearances, structure and base attachment, piping, power, controls, and flues. Each view shows a screened background with the following:

1. Column grids, beams, columns, and concrete housekeeping pads.
2. Room layout with walls, floors, and roofs, including each room name and number.
3. Equipment and products of other trades that are located in vicinity of boilers and are part of final installation, such as lighting, fire-suppression systems. and plumbing systems.

- B. Seismic Qualification Certificates: For boilers, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Installation instructions.
- D. Source quality-control reports.
- E. Field quality-control reports.
- F. Sample Warranty: For special warranty.
- G. Other Informational Submittals:
 - 1. ASME "A" Stamp Certification and Report: Submit "A" stamp certificate of authorization as required by authorities having jurisdiction, and document hydrostatic testing of piping external to boiler.
 - 2. Startup service reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For boilers, components, and accessories to include in emergency, operation, and maintenance manuals.
- B. Spare Parts List: Recommended spare parts list with quantity for each.
- C. Touch-up Paint Description: Detailed description of paint used in application of finish coat to allow for procurement of a matching paint.
- D. Instructional Videos: Including those that are prerecorded and those that are recorded during training.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Tool kit to include the following:
 - 1. A tool kit specially designed by boiler manufacturer for use in servicing boiler(s) furnished.
 - 2. Special tools required to service boiler components not readily available to Owner service personnel in performing routine maintenance.
 - 3. Lockable case with hinged cover, marked with large and permanent text to indicate the special purpose of tool kit, such as "Boiler Tool Kit." Text size shall be at least 1 inch ((25 mm)) high.

4. A list of each tool furnished. Permanently attach the list to underside of case cover. Text size shall be at least **0.5 in. (13 mm)** high.
- B. Touch-up Paint: [**32-oz. (1-L)**] **<Insert volume>** container of paint used for finish coat. Label on outside of container shall have a detailed description of paint to allow for procurement of a matching paint in the future.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Ship boilers from the factory free of water. Drain water and blow dry with compressed air if required to remove all water before shipping.
- B. Cover and protect flue, electrical controls, and piping connections before shipping. Protect and seal openings and connections with blinds, caps, plugs, and other materials during delivery, storage, and handling.
- C. Protect boiler components with removable temporary enclosures to prevent damage during shipping, storage, and installation.
- D. Package boiler for export shipping in totally enclosed [**bagging**] [**crate**] [**crate with bagging**].

1.8 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace heat exchangers damaged by thermal shock and vent dampers of boilers that fail in materials or workmanship within specified warranty period.
 1. Warranty Period for Heat Exchangers: [**20**] **<Insert number>** years from date of Substantial Completion.
 2. Warranty Period for Vent Dampers: [**Five**] **<Insert number>** years from date of Substantial Completion.
- B. Special Warranty: Manufacturer agrees to repair or replace drums, tubes, headers, cabinets, atmospheric gas burners, and pressure vessels of boilers that fail in materials or workmanship within specified warranty period.
 1. Warranty Period for Drums, Tubes, Headers, Cabinets, and Atmospheric Gas Burner: [**Five**] **<Insert number>** years from date of Substantial Completion, pro rata.
 2. Warranty Period for Pressure Vessel: [**20**] **<Insert number>** years from date of Substantial Completion, for thermal shock.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Fuel-to[**steam**] [**water**] efficiency indicated shall be based on the following:
 1. Efficiency Testing Method: BTS-2000.

2. Efficiency Testing Method: ASME Performance Test Code (PTC) 4, **[Input-Output]** **[Heat Loss]** method.
 3. Efficiency Testing Method: **<Insert test requirement>**.
 4. Test Operating Conditions:
 - a. Ambient Temperature: **<Insert temperature>**.
 - b. Ambient Relative Humidity: **<Insert relative humidity>**.
 - c. Percent Excess Air in Exhaust Flue Gas: **[15]** **<Insert number>**.
 - d. Fuel Heating Value: **<Insert value>**.
- B. Gas-Fired Boiler Emissions: Not to exceed allowable ambient-air quality standards in governing jurisdiction and indicated values.
1. Carbon monoxide:
 - a. **[50]** **<Insert number>** parts per million at any point from 100 percent to **[50]** **<Insert number>** percent fire.
 - b. **[150]** **<Insert number>** parts per million at any point below **[50]** **<Insert number>** percent fire.
 2. Nitrogen compounds: **[30]** **[20]** **[10]** **<Insert number>** parts per million (dry volume basis and corrected to **[3]** **<Insert number>** percent oxygen) at any point from 100 percent to low fire.
 3. Sulfur compounds: **[One]** **<Insert number>** part per million (dry volume basis and corrected to **[3]** **<Insert number>** percent oxygen) at any point from 100 percent to low fire.
 4. Hydrocarbon and Volatile Organic Compounds: **[10]** **<Insert number>** parts per million (dry volume basis and corrected to **[3]** **<Insert number>** percent oxygen) at any point from 100 percent to low fire.
 5. Particulate Matter: **[0.01 lb/MMBtu]** **<Insert value>**.
 6. Smoke: Not visible and not to exceed No. 1 on the Bacharach smoke scale.
- C. Oil-Fired Boiler Emissions: Not to exceed allowable ambient-air quality standards in governing jurisdiction and indicated values.
1. Carbon monoxide:
 - a. **[50]** **<Insert number>** parts per million at any point from 100 percent to **[50]** **<Insert number>** percent fire.
 - b. **[150]** **<Insert number>** parts per million at any point below **[50]** **<Insert number>** percent fire.
 2. Nitrogen compounds: **[30]** **[20]** **[10]** **<Insert number>** parts per million (dry volume basis and corrected to **[3]** **<Insert number>** percent oxygen) at any point from 100 percent to low fire.
 3. Sulfur compounds: **[One]** **<Insert number>** part per million (dry volume basis and corrected to **[3]** **<Insert number>** percent oxygen) at any point from 100 percent to low fire.
 4. Hydrocarbon and Volatile Organic Compounds: **[10]** **<Insert number>** parts per million (dry volume basis and corrected to **[3]** **<Insert number>** percent oxygen) at any point from 100 percent to low fire.

5. Particulate Matter: **[0.01 lb/MMBtu] <Insert value>**.
 6. Smoke: Not visible and not to exceed No. 1 on the Bacharach smoke scale.
- D. Multiple Boiler Operation: Equip individual boilers in multiple boiler applications with integral controls to provide multiple boiler operation for optimum system performance, energy efficiency, and the following:
1. Equalize runtime of boilers in service.
 2. Operate multiple boilers hot to minimize disruption of service in the event of single boiler failure.
 3. Configure controls so any boiler can be taken out of service with power disconnected and not impact multiple boiler operation.
 4. **<Insert requirement>**.
- E. Seismic Performance: Boiler shall withstand the effects of earthquake motions determined according to **[ASCE/SEI 7] <Insert requirement>**.
1. The term "withstand" means "the boiler will remain in place without separation of any parts when subjected to the seismic forces specified[**and the boiler will be fully operational after the seismic event**]."
 2. Component Importance Factor: **[1.5] [1.0]**.
 3. **<Insert requirements for Component Amplification Factor and Component Response Modification Factor>**.
- F. Sound: Boiler sound level, measured according to parameters defined in ABMA publication "Boiler 304 Measurement of Sound from Steam Generators" shall not exceed **<Insert number>** dBA.
- G. Steam Quality: **[99] [99.5] <Insert number>** percent dry[**and saturated**].
- H. Operation Following Loss of Normal Power:
1. Equipment, associated factory- and field-installed controls, and associated electrical equipment and power supply connected to back-up power system shall automatically return equipment and associated controls to the operating state occurring immediately before loss of normal power without need for manual intervention by an operator when power is restored either through a back-up power source or through normal power if restored before back-up power is brought online.
 2. Refer to Drawings for equipment served by back-up power systems.
 3. Provide means and methods required to satisfy requirement even if not explicitly indicated.
- I. Outdoor Installations:
1. Boiler shall be suitable for outdoor installation indicated. Provide adequate weather protection to ensure reliable service life over a **[25] <Insert number>** -year period, with minimal degradation due to exposure to outdoor ambient conditions.
 2. Boilers equipped to provide safe and stable operation while achieving performance indicated when operating at extreme outdoor temperatures encountered by the installation. Review historical weather database and provide equipment that can operate at extreme outdoor temperatures recorded over past **[30] <Insert number>** -year period.

Provide as part of boiler package, products, such as combustion-air pre-heaters and other means and methods required.

- J. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- K. ASME Compliance: Fabricate and label boilers to comply with 2010 ASME Boiler and Pressure Vessel Code.
- L. ASHRAE/IES 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."
- M. DOE Compliance: Minimum efficiency for boilers with capacity of **300,000 Btu/h (87.9 kW)** shall comply with 10 CFR 430, Subpart B, Appendix N, "Uniform Test Method for Measuring the Energy Consumption of Furnaces and Boilers."
- N. UL Compliance: Test boilers for compliance with **[UL 726] [UL 726 and UL 795] [UL 795]**. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

2.2 FINNED WATER-TUBE BOILERS

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Description: Factory-fabricated, -assembled, and -tested boiler, with tubes sealed into headers pressure tight, and set on a steel base; including insulated jacket, flue-gas vent, combustion-air-intake connections, water supply and return connections, and controls.
- C. Heat Exchanger:
 - 1. Finned **[copper] [steel] [or] [copper-nickel]** tubing with stainless-steel baffles.
 - 2. **[Bronze] [Cast-iron] [or] [Steel]** headers.
 - 3. **[Single] [Two]**-pass, **[horizontal] [vertical] [or] [coil]** configuration.
 - 4. Tubes shall be sealed in header **[with silicone O-ring gaskets] [by welding] [or] [by mechanically rolling tubes in header]**.
- D. Combustion Chamber Internal Insulation: Interlocking panels of refractory insulation, high-temperature cements, mineral fiber, and ceramic refractory tile for service temperatures of up to **2000 deg F (1100 deg C)**.
- E. Casing:
 - 1. Jacket: **[Sheet metal] [or] [Stainless steel]**, with snap-in or interlocking closures.
 - 2. Control Compartment Enclosure: NEMA 250, Type 1A.
 - 3. Finish: **[Baked enamel over primer] [Baked enamel over galvanizing] [Powder coated]**.
 - 4. Insulation: Minimum **[1-inch- (25-mm-)] [2-inch- (50-mm-)]** **<Insert value>** thick, mineral-fiber insulation surrounding the heat exchanger.
 - 5. Draft Hood: **[Integral] [External]**.

6. Combustion-Air Connection: Inlet duct collar and sheet metal closure over burner compartment.
7. Mounting base to secure boiler[**with accessory for mounting on combustible surface**].

F. Burner:

1. Burner Tubes and Orifices: Stainless steel, for [natural] [propane] gas.[**Mount burner tubes in a slide-out burner drawer for ease of inspection.**]
 - a. Sealed Combustion: Factory-mounted centrifugal fan to draw outside air into boiler and discharge into burner compartment.
 - b. Direct Vent: Factory-mounted centrifugal fan to draw flue gas out of boiler and discharge into boiler vent.
2. Vertical Burner:
 - a. **[High-temperature stainless steel] [Ceramic]** to fire in a 360-degree pattern.
 - b. Burner shall have a viewing port for observation of burner operation and a factory-mounted centrifugal fan to supply [room] [outdoor] air[**through a replaceable 99 percent efficient (1-micrometer particles) filter**] to boiler burner.
 - c. Fan shall be controlled to prepurge and postpurge the combustion chamber before firing.
3. Gas Train: Control devices and [full-modulation] [on/off] [low/high/low] [proportional] control sequence shall comply with [AGA] [ASME CSD-1] [FM Global] [Industrial Risk Insurers (IRI)] [and] [or] [UL] requirements. In addition to these requirements, include shutoff cock, pressure regulator, and control valve.
4. Gas Train: Combination gas valve with manual shutoff, pressure regulator, and pilot adjustment.
5. Pilot: [Standing] [Intermittent-electric-spark] [Hot-surface] pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.
6. Flue-Gas Recirculation System: Centrifugal fans on burner assembly to recirculate flue gas to decrease emissions to requirements indicated. Complete package integrating burner, fan, damper, fuel train, and controls. Provide interconnecting external ducting if required by manufacturer's design.
7. Motors: Comply with requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

G. Hot-Water Boiler Trim:

1. Hot-Water Temperature Controllers: Operating[, **firing rate,**] and high limit.
2. Safety Relief Valve: ASME rated.
3. Pressure and Temperature Gage: Minimum **3-1/2-inch- (89-mm-)** diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges, so normal operating range is about 50 percent of full range.
4. Boiler Air Vent: [Automatic] [Manual].
5. Drain Valve: Minimum **NPS 3/4 (DN 20)** hose-end valve.
6. Circulation Pump: Non-overloading, in-line pump with [split-capacitor] motor having thermal-overload protection and lubricated bearings; designed to operate at boiler flow rate, pressures, and temperatures.

H. Controls:

1. Boiler operating controls shall include the following devices and features:
 - a. Control transformer.
 - b. Motorized Vent Damper: Interlocked with burner to open before burner starts. If damper fails to open, stop burner operation.
 - c. Set-Point Adjust: Set points shall be adjustable.
 - d. Sequence of Operation: Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain space temperature in response to thermostat with heat anticipator located in heated space.
 - e. Sequence of Operation: Electric, factory-fabricated and field-installed panel to control burner firing rate to reset supply-water temperature inversely with outdoor-air temperature. At [**0 deg F (minus 17 deg C)**] **<Insert temperature>** outdoor-air temperature, set supply-water temperature at [**200 deg F (93 deg C)**] **<Insert temperature>**; at [**60 deg F (15 deg C)**] **<Insert temperature>** outdoor-air temperature, set supply-water temperature at [**140 deg F (60 deg C)**] **<Insert temperature>**.
 - f. Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.
2. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation.
 - a. High Cutoff: [**Manual**] [**Automatic**] reset stops burner if operating conditions rise above maximum boiler design temperature.
 - b. Water Flow Switch: Automatic-reset paddle-switch shall prevent burner operation on low water flow.
 - c. Blocked Vent Safety Switch: Manual-reset switch factory mounted on draft diverter.
 - d. Rollout Safety Switch: Factory mounted on boiler combustion chamber.
 - e. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.
3. [**Building Automation**] [**DDC**] System Interface: Factory install hardware and software to enable system to monitor, control, and display boiler status and alarms.
 - a. Hardwired I/O Points:
 - 1) Monitoring: On/off status, [**common trouble alarm**] [**low-water-level alarm**] **<Insert monitoring point>**.
 - 2) Control: On/off operation, [**hot-water-supply temperature set-point adjustment**] **<Insert control point>**.
 - b. Communication Interface: [**ASHRAE 135 (BACnet)**] [**(LonTalk)**] [**Modbus**] [**Industry-accepted, open-protocol**] **<Insert type of interface>** communication interface shall enable control system operator to remotely control on/off operation and capacity of boiler and monitor the boiler operation from an operator workstation. The control features and monitoring points at the boiler-control panel shall be available to the control system through an interface.

2.3 STEEL OR FLEXIBLE WATER-TUBE BOILERS

- A. [<Double click here to find, evaluate, and insert list of manufacturers and products.>](#)
- B. Description: Factory-fabricated and [field]-assembled water-tube boiler, with heat exchanger sealed pressure tight, and built on a steel base; including insulated jacket, flue-gas vent, supply and return connections, and controls.
- C. Heat-Exchanger Design: Straight steel tubes rolled into steel headers.
1. Accessible head plates at both ends.
 2. Handholes[**or couplings**] in headers for waterside inspections.
 3. Accessible drain and blowdown tappings, both high and low, for surface and mud removal.
 4. Lifting lugs on top of boiler.
 5. Built-in air separator.
- D. Heat-Exchanger Design: Bent steel tubes [swaged] [welded] into steel headers[**with membrane waterwall design**].
1. Limit tube configurations to [two] [four] <Insert number>.
 2. Accessible drain and blowdown tappings, both high and low, for surface and mud removal.
 3. Accessible inspection ports in drum, mud legs, and tube manifolds.
 4. Lifting lugs on top of boiler.
 5. Built-in air separator.
- E. Combustion Chamber: Equipped with minimum [2-1/2-inch (64-mm)] [3-inch (75-mm)] [4-inch (100-mm)], 2700 deg F (1482 deg C) poured refractory on floor and minimum [2-inch (50-mm)] [3-1/2-inch (89-mm)] <Insert value> lap-jointed cast refractory with fiber-blanket joint seals on side walls. Combustion chamber shall have flame observation ports in front [and] [or] back.
- F. Casing:
1. Insulation: Minimum[**2-inch (50-mm) thick, lightweight refractory; 1-inch (25-mm) thick insulating board; galvanized-steel membrane; and** 2-inch (50-mm) thick, mineral-fiber insulation surrounding the heat exchanger and combustion chamber.
 2. Top Flue Connection: Constructed of [aluminized] [or] [stainless] steel.
 3. Jacket: Mirror-finish stainless steel, with screw-fastened closures.
 4. Jacket: [Galvanized] sheet metal, with screw-fastened closures and [baked-enamel] [powder-coated] protective finish.
 5. Mounting Base: Secures boiler to concrete base.
- G. [Draft Diverter] [Barometric Damper]: Galvanized-steel assembly with flue-gas thermometer.
- H. Atmospheric Gas Burner:
1. Burner and Orifices: [Stainless steel] [Cast iron], for [natural] [propane] gas.

2. Gas Train: Control devices and [full-modulation] [on/off] [low/high/low] control sequence shall comply with [ASME CSD-1] [FM Global] [NFPA 85] [Industrial Risk Insurers (IRI)] [and] [or] [UL] requirements.
3. Gas Train: Combination gas valve with manual shutoff, pressure regulator, and pilot adjustment.
4. Pilot: [Standing] [Intermittent-electric-spark] pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.

I. Forced-Draft Gas Burner:

1. Burner: Welded construction with multivane, stainless-steel, flame-retention diffuser for [natural] [propane] gas. [Mount burner on hinged access door to permit access to combustion chamber.]
2. Blower: Forward-curved centrifugal fan integral to burner, directly driven by motor; with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.
3. Gas Train: Control devices and [modulating] [on/off] [low/high/low] control sequence shall comply with [ASME CSD-1] [FM Global] [NFPA 85] [Industrial Risk Insurers (IRI)] [and] [or] [UL] requirements.
4. Pilot: [Intermittent] [Interrupted]-electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.

J. Forced-Draft Oil Burner:

1. Burner: Welded construction with multivane, stainless-steel, flame-retention diffuser for fuel oil. [Mount burner on hinged access door to permit access to combustion chamber.]
2. Blower: Forward-curved centrifugal fan integral to burner, directly driven by motor; with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.
3. Oil Supply: Control devices and [modulating] [on/off] [low/high/low] control sequence shall comply with [ASME CSD-1] [FM Global] [NFPA 85] [Industrial Risk Insurers (IRI)] [and] [or] [UL] requirements.
 - a. Oil Pump: Two-stage, gear-type oil pump [integral to and directly driven by blower] shall be capable of producing 300-psig (2070-kPa) discharge pressure and 15-inch Hg (50.7-kPa) vacuum.
 - b. Oil Piping Specialties:
 - 1) Suction-line, manual, gate valve.
 - 2) Removable-mesh oil strainer.
 - 3) 0- to 30-inch Hg (0- to 101.3-kPa) vacuum; 0- to 30-psig (0- to 207-kPa) vacuum-pressure gage.
 - 4) 0- to 300-psig (0- to 2070-kPa) oil-nozzle pressure gage.
 - 5) Nozzle-line, solenoid-safety-shutoff oil valve.
4. Pilot: [Intermittent] [Interrupted]-electric-spark pilot ignition with 100 percent main-valve and pilot-safety-shutoff solenoid using [cadmium sulfide] [UV scanner] flame-safety control.

K. Forced-Draft Combination Gas and Oil Burner:

1. Burner: Welded construction with multivane, stainless-steel, flame-retention diffuser for fuel oil and **[natural] [propane]** gas. **[Mount burner on hinged access door to permit access to combustion chamber.]**
 2. Blower: Forward-curved centrifugal fan integral to burner, directly driven by motor; with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.
 3. Oil Supply: Control devices and **[modulating] [on/off] [low/high/low]** control sequence shall comply with **[ASME CSD-1] [FM Global] [NFPA 85] [Industrial Risk Insurers (IRI)] [and] [or] [UL]** requirements.
 - a. Oil Pump: Two-stage, gear-type oil pump **[integral to and directly driven by blower]** shall be capable of producing **300-psig (2070-kPa)** discharge pressure and **15-inch Hg (50.7-kPa)** vacuum.
 - b. Oil Piping Specialties:
 - 1) Suction-line, manual, gate valve.
 - 2) Removable-mesh oil strainer.
 - 3) **0- to 30-inch Hg (0- to 101.3-kPa)** vacuum; **0- to 30-psig (0- to 207-kPa)** vacuum-pressure gage.
 - 4) **0- to 300-psig (0- to 2070-kPa)** oil-nozzle pressure gage.
 - 5) Nozzle-line, solenoid-safety-shutoff oil valve.
 4. Gas Train: Control devices and **[modulating] [on/off] [low/high/low]** control sequence shall comply with **[ASME CSD-1] [FM Global] [NFPA 85] [Industrial Risk Insurers (IRI)] [and] [UL]** requirements.
 5. Gas Pilot: **[Intermittent] [Interrupted]**-electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.
 6. Oil Pilot: **[Intermittent] [Interrupted]**-electric-spark pilot ignition with 100 percent main-valve and pilot-safety-shutoff solenoid with **[cadmium sulfide] [UV scanner]** flame-safety control.
- L. Motors: Comply with requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment" unless more stringent requirements are indicated below:
1. Efficiency: **[Premium efficient] <Insert requirement>**.
 2. Enclosure: **[Open dripproof] [Totally enclosed] [or] [Totally enclosed, fan cooled]**.
 3. Insulation Class: **[F] [H] <Insert requirement>**.
 4. Service Factor: **[1.15] <Insert value>**.
 5. Motors operated through variable-frequency controllers shall be inverter duty rated according to NEMA MG-1.
 6. Motor Sizes: Minimum size as indicated and large enough so driven load does not require motor to operate in service factor.
- M. Flue-Gas Recirculation System:
1. Equip boiler with packaged flue-gas recirculation system if required to satisfy emission requirements.
 2. Complete package integrating burner, combustion-air blower and damper, fuel train, and controls. Provide interconnecting external ducting if required by manufacturer's design.
- N. Hot-Water Boiler Trim:

1. Include devices sized to comply with [ASME B31.1] [ASME B31.9].
2. Hot-Water Temperature Controllers: Operating[, **firing rate**,] and high limit.
3. Safety Relief Valve: ASME rated.
4. Pressure and Temperature Gage: Minimum **3-1/2-inch- (89-mm-)** diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges, so normal operating range is about 50 percent of full range.
5. Boiler Air Vent: [**Automatic**] [**Manual**].
6. Drain Valve: Minimum **NPS 3/4 (DN 20)** hose-end valve.
7. Tankless Heater: [**Carbon-steel**] [**Bronze**] header with copper-tube heat exchanger, mounted in a port of upper drum and sealed with fiber gasket.
 - a. Tappings **NPS 2 (DN 50)** and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.
 - b. Tappings **NPS 2-1/2 (DN 65)** and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.

O. Steam Boiler Trim:

1. Include devices sized to comply with [ASME B31.1] [ASME B31.9].
2. Pressure Controllers: Operating[, **firing rate**,] and high limit.
3. Safety Relief Valve:
 - a. Size and Capacity: As required for equipment according to 2010 ASME Boiler and Pressure Vessel Code.
 - b. Description: Fully enclosed steel spring with adjustable pressure range and positive shutoff; factory set and sealed.
 - 1) Drip-Pan Elbow: Cast iron and having threaded inlet and outlet with threads complying with ASME B1.20.1.
 - 2) Exhaust Head: Install exhaust head on vent pipe connected to safety relief valve.
4. Pressure Gage: Minimum **3-1/2-inch (89-mm)** diameter. Gage shall have normal operating pressure of about 50 percent of full range.
5. Water Column: Minimum **12-inch (300-mm)** glass gage with gage rods to protect glass, ball check and shutoff cocks, water column blowdown valves, and vacuum breaker. Midpoint of gauge shall be at normal operating water level.
6. Bottom Blowdown Valves: Factory-installed, duty-rated, slow-acting blowdown valves and interconnecting piping same size as boiler nozzle.[**Blowdown valves shall be combination of slow and quick acting as required by ASME B31.1.**]
7. Surface Blowdown Valves: Factory-installed, duty-rated isolation valves and interconnecting piping.[**In addition, provide electrically operated control valve, duty rated, to control total dissolved solids (TDS) through boiler controls.**]
8. Stop Valves: Boiler outlets, except safety relief valves, shall be equipped with stop valve in an accessible location as near as is practical to boiler nozzle and same size or larger than nozzle. Valves larger than **NPS 2 (DN 50)** shall have rising stem.
9. Stop-Check Valves: Factory-installed, stop-check valve and stop valve at boiler outlet with free-blow drain valve factory installed between the two valves and visible when operating stop-check valve.

10. Feedwater Valves: Factory-installed, duty-rated stop and check valves and interconnecting piping. Stop valves larger than **NPS 2 (DN 50)** shall have rising stem.
11. Feedwater Valves: Factory-installed, three-valve bypass arrangement with modulating control valve positioned between duty-rated stop valves, bypass piping with throttling valve, check valve, and interconnecting piping. Stop and throttling valves larger than **NPS 2 (DN 50)** shall have rising stem. Modulating control valve shall have the following features and characteristics:
 - a. Duty rated with electric operator to control water level through boiler controls.
 - b. Equal percentage flow characteristic.
 - c. Valve Flow: **[Indicated on Drawings] [1.25 times boiler output] <Insert requirement>**.
 - d. Valve Pressure and Temperature Rating: Equal to boiler.
 - e. Shut-off Leakage: **[0.0001] <Insert number>** percent of valve coefficient.
12. Chemical Injection Assembly: Factory-installed, duty-rated injection quill with ball check valve and isolation valve compatible with dispensed chemical.
13. Sample Cooler: Factory **[installed] [or] [furnished for field installation]**, with **[needle]** valve for each connection. **[Constructed of 316 stainless steel.]**
14. Tankless Heater: Carbon-steel header with copper-tube heat exchanger, mounted in a port of upper manifold and sealed with fiber gasket.
 - a. Tappings **NPS 2 (DN 50)** and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.
 - b. Tappings **NPS 2-1/2 (DN 65)** and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.

P. Controls:

1. Boiler operating controls shall include the following devices and features:
 - a. Control transformer(s) with fuse protection, as required by manufacturer, to implement requirements indicated. Provide transformer with 25 percent spare capacity.
 - b. Set-Point Adjust: Operating and alarm set points shall be field adjustable.
2. Pressure Control for Steam Boilers:
 - a. Operating-Pressure Control: Factory wired and mounted to control boiler to maintain boiler at constant pressure within **[2] <Insert number>** percent of set point.
 - b. High-Pressure Cutoff with Automatic Reset: Control stops burner if operating conditions rise above normal operating-pressure set point. Set point shall be adjustable.
 - c. High-Pressure Cutoff with Manual Reset: Control stops burner operation upon reaching adjustable high limit set point that is below safety valve setting.
3. Water-Level Control for Steam Boilers:

- a. Operating Water-Level Control: **[Cycle feedwater pump(s)] [Operate feedwater pump(s) continuously and modulate boiler feedwater valve]** for water-level control.
 - b. Low-Water Cutoff Switch: **[Electronic] [Float and electronic]** probe shall prevent burner operation on low water. Cutoff switch shall be **[manual] [automatic]**-reset type.
 - c. Auxiliary Low-Water Cutoff Switch: **[Electronic] [Float and electronic]** probe shall prevent burner operation on low-water alarm limit. Cutoff switch shall be manual-reset type.
 - d. Microprocessor-based control.
 - e. Accuracy within **[0.01 in. (0.25 mm)] <Insert value>**.
 - f. Visual indication of level, alarms, and errors through alphanumeric display.
 - g. Features:
 - 1) Continuous water-level indication.
 - 2) Low-water cutoff and alarm.
 - 3) High-water alarm.
 - 4) Low- and high-water warning.
 - 5) Control of feedwater pump.
 - 6) Control of modulating feedwater control valve.
 - 7) Continuous monitoring of float operation.
 - 8) Column blowdown detection and reminder.
 - 9) Auxiliary low-water cutoff check.
 - 10) Auto and manual reset.
 - 11) Alarm annunciation.
 - 12) **<Insert feature>**.
4. Operating Controls for Hot-Water Boilers:
- a. Sequence of Operation: Electric, factory-fabricated and field-installed panel to control burner firing rate to reset supply-water temperature inversely with outdoor-air temperature. At **[0 deg F (minus 17 deg C)] <Insert temperature>** outdoor-air temperature, set supply-water temperature at **[200 deg F (93 deg C)] <Insert temperature>**; at **[60 deg F (15 deg C)] <Insert temperature>** outdoor-air temperature, set supply-water temperature at **[140 deg F (60 deg C)] <Insert temperature>**.
 - b. Sequence of Operation: Indicated on Drawings.
 - c. Sequence of Operation: **<Insert requirements>**.
5. Multiple Boiler Operation: Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.
6. Boiler Emergency Shutdown: Interlock with field-installed boiler emergency shutdown switch to shut down boiler when activated. Manufacturer to furnish break-glass-type switch with permanent nameplate titled "Boiler Emergency Shutdown" for field installation.
7. Chemical Feed System Interface: Dry contacts to interface control and operation of chemical feed pump.
8. Burner Safety Controls for Steam Boilers: To maintain safe operating conditions, burner safety controls limit burner operation.

- a. High Cutoff: **[Automatic]** **[and]** **[Manual]** reset stops burner if operating conditions rise above maximum boiler operating pressure.
 - b. Low-Water Cutoff Switch: Float and electronic probe shall prevent burner operation on low water. Cutoff switch shall be automatic-reset type.
 - c. Auxiliary Low-Water Cutoff Switch: Float and electronic probe shall prevent burner operation on low-water alarm limit. Cutoff switch shall be manual-reset type.
 - d. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.
9. Burner Safety Controls for Hot-Water Boilers: To maintain safe operating conditions, burner safety controls limit burner operation.
- a. High Cutoff: **[Automatic]** **[and]** **[Manual]** reset stops burner if operating conditions rise above boiler design temperature.
 - b. Low-Water Cutoff Switch: Electronic probe shall prevent burner operation on low water. Cutoff switch shall be **[manual]** **[automatic]**-reset type.
 - c. Auxiliary Low-Water Cutoff Switch: Electronic probe shall prevent burner operation on low-water alarm limit. Cutoff switch shall be manual-reset type.
 - d. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.
10. Burner Flame Safeguard Controls:
- a. Factory equipped with flame safeguard control and infrared flame scanner.
 - b. Microprocessor-based, solid-state control having sequence and flame-on visual indication and fault code indications of flame safeguard trip functions.
 - c. Control shall include dynamic self-check logic.
 - d. Control shall have a fixed operating sequence incapable of being manually altered that includes start, prepurge, pilot and main fuel ignition run, and postpurge cycles.
 - e. Control shall be nonrecycle type for maximum safety that shall shut down the burner and indicate, as a minimum, the following trip functions:
 - 1) Pilot and main flame failure.
 - 2) High- and low-fire proving switch faults.
 - 3) Running interlocks open.
 - 4) False flame signal and fuel valve open.
 - f. Control shall include a run/test switch to allow interruptions to sequence just after prepurge and during pilot ignition trial, and run cycles for adjustments to firing rate motor, damper linkages, and pilot flame for minimum turndown tests.
11. Combustion-Air Controls: Factory equipped with motor-operated combustion-air damper and blower control to regulate burner fire according to load demand.
12. Oxygen Trim Control:
- a. Provide oxygen trim system to continuously monitor and display oxygen concentrations in boiler flue gas and adjust fuel and airflow to maintain an adjustable oxygen-level set point.
 - b. System shall compensate for changes in ambient temperature, barometric pressure, humidity, and variations in fuel characteristics.

13. Surface Blowdown Control: Provide a conductivity sensor and control circuitry to operate an automatic control valve in surface blowdown piping to maintain total dissolved solids(TDS) within boiler manufacturer's prescribed level.
14. **[Building Automation] [DDC]**System Interface: Factory install hardware and software to enable system to monitor, control, and display boiler status and alarms.
 - a. Hardwired I/O Points:
 - 1) Monitoring: On/off status, **[common trouble alarm] [low-water-level alarm] <Insert monitoring points>**.
 - 2) Control: On/off operation, **[hot-water-supply temperature set-point adjustment] [steam pressure adjustment] <Insert control points>**.
 - b. Communication Interface: **[ASHRAE 135 (BACnet)] [(LonTalk)] [Modbus] [Industry-accepted, open-protocol]** **<Insert type of interface>** communication interface shall enable control system operator to remotely control on/off and capacity of boiler and monitor the boiler operation from an operator workstation. Control features are available, and monitoring points are displayed locally at boiler control panel through the interface.
15. Integrated Boiler Control System:
 - a. Integral control of burner management for flame safety, boiler modulation, and operator interface functions with features and functions indicated.
 - b. Factory preconfigured.
 - c. Utilizing solid-state controls and sensors to provide various control functions, including the following:
 - 1) Automatic sequencing of the boiler through standby, prepurge, pilot flame establishing period, main flame establishing period, run, flame proving and lockout, and postpurge.
 - 2) Full modulating control of air and fuel through Proportional-Integral-Derivative (PID) algorithm.
 - 3) Thermal shock protection.
 - 4) High and low limit alarms and shutdowns.
 - d. Local operator interface through nominal **[10-inch ((250-mm))]** **<Insert size>** color touch screen graphical display for setup, monitoring, and data acquisition.
 - 1) Manual control of the boiler firing rate using control screens to increment or decrement firing rate.
 - 2) Indication of burner management controller status and diagnostics.
 - 3) Display of system alarms and faults.
 - 4) Display of history of alarms and faults.
 - 5) Display of recommendations for troubleshooting of fault conditions.
 - 6) Display of water-level indication and alarm(s).
 - 7) Stack flue-gas, combustion-air, and shell water-temperature indication.
 - 8) Boiler efficiency calculation and display.
 - 9) Low-fire hold with minimum temperature control.
 - 10) Assured low-fire cutoff (ALFCO).
 - 11) High stack temperature annunciation with auto cutoff.

- 12) Audible alarm and silencing through touch screen intervention.
 - e. Fully integrated control of the following:
 - 1) Blower operation and combustion-air damper for varying operating conditions.
 - 2) Oxygen trim and monitoring to compensate for combustion-air variations.
 - 3) Parallel positioning for independent fuel and air control for enhanced fuel efficiency.
 - 4) Multiple boiler lead/lag control with hot standby.
 - 5) Draft control for maintaining proper and consistent draft for enhanced fuel efficiency.
 - 6) **<Insert additional features>**.
 - f. E-mail and paging feature to multiple contacts via Internet and phone line independent of control system interface.
 - g. LAN/WAN interface with remote monitoring software to allow remote monitoring independent of control system interface.
16. Control Enclosures:
- a. NEMA 250, Type [1] **<Insert type>**.
 - 1) Provide enclosure with integral vents, fans, heater, and air conditioner as required to automatically control temperature inside enclosure within safe operating limits of devices installed within the enclosure.
 - b. Wiring shall be numbered and color-coded to match wiring diagram. [**Provide a laminated wiring diagram located inside enclosure.**]
 - c. Mounted on boiler assembly at a location convenient to operator.
 - d. Provide hinged full-size door with key lock. Provide common key for all locks.
 - e. Enclosure shall consist of multiple sections divided by a partition with a separate hinged door for each section. One section shall house low-voltage controls and other section shall house line voltage controls.
 - f. Enclosure shall house the following:
 - 1) Control transformers with fuses.
 - 2) Labeled terminal strips.
 - 3) Controller(s) to provide control and alarm functions indicated.
 - 4) Audible indication of safety alarms.
 - g. Face of enclosure shall provide the following:
 - 1) Visual indication of operating components and alarms.
 - 2) Auto/local capability to allow operator to manually operate boiler locally.
 - 3) Audible alarm-silence capability.
 - 4) Labels for switches, lights, and displays to provide clear indication of service.

17. Control Instrument Enclosures: Control instruments and devices that are mounted on the boiler assembly and cannot be installed inside the control enclosure shall have same or higher level of protection indicated for control enclosures.
18. Control Cable and Wire:
 - a. Control cable and wiring shall be numbered and color-coded to match wiring diagram.
 - b. Install cable and wiring located outside of enclosure(s) in a **[metal]** raceway. Use flexible conduit to make final terminations. Provide watertight installation for applications exposed to moisture.

2.4 ELECTRICAL POWER

- A. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.
 1. Enclosure: NEMA 250, Type **[1]** **<Insert type>**.
 - a. Enclosure shall have integral vents, fans, heat, and air conditioner as required to automatically control temperature inside enclosure within safe operating limits of devices installed within the enclosure.
 - b. Mounted on boiler assembly at a location convenient to operator.
 - c. Enclosure shall have hinged full-size door with key lock with common key for all locks.
 2. Wiring shall be numbered and color-coded to match wiring diagram. **[Provide a laminated wiring diagram located inside enclosure.]**
 3. Install factory wiring outside of an enclosure in a **[metal]** raceway. Make final connections to motors using flexible conduit. Provide watertight installation for applications exposed to moisture.
 4. Field power interface shall be to **[fused disconnect switch]** **[nonfused disconnect switch]** **[circuit breaker]**. Withstanding rating of disconnecting means shall protect equipment. Coordinate requirements with field electrical power source.
 5. Provide branch power circuit to each motor and to controls **[with disconnect switch or circuit breaker]**.
 6. Provide each motor with NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection. Provide variable-frequency controller with manual bypass and line reactors for each variable-speed motor indicated.
 7. Provide transformer with fuses and power wiring to power a 20-A 120-V duplex receptacle mounted in each boiler control panel for use in connecting analytical and testing equipment.

2.5 VENTING KITS

- A. Vent Damper: Motorized; UL listed for use on atmospheric burner boiler equipped with draft hood; motor to open and close damper; stainless-steel vent coupling and damper blade; keyed wiring harness connector plug; and dual-position switches to permit burner operation.

- B. Kit: Complete system, [ASTM A 959, Type 29-4C]stainless steel, pipe, vent terminal, thimble, indoor plate, vent adapter, condensate trap, and sealant.
- C. Combustion-Air Intake: Stainless steel, pipe, vent terminal with screen, inlet air coupling, and sealant.

2.6 CAPACITIES AND CHARACTERISTICS

- A. Heating Medium: [Hot water] [Steam].
- B. Design Pressure and Temperature Rating: [160 psig (1100 kPa), 250 deg F (120 deg C)] <Insert values>.
- C. Design Pressure Rating: [60 psig (420 kPa)] [100 psig (690 kPa)] [140 psig (966 kPa)] [160 psig (1100 kPa)] <Insert value>.
- D. Design Pressure Rating: [15 psig (104 kPa)] [150 psig (1035 kPa)] [250 psig (1725 kPa)] <Insert value>.
- E. Safety Relief Valve Setting: <Insert psig (kPa)>.
- F. Entering-Water Temperature: <Insert deg F (deg C)>.
- G. Leaving-Water Temperature: <Insert deg F (deg C)>.
- H. Design Water-Flow Rate: <Insert gpm (L/s)>.
- I. Design Pressure Drop: <Insert psig (kPa)>.
- J. Steam Operating Pressure: <Insert psig (kPa)>.
- K. Steam-Flow Rate: <Insert lb/h (kg/s)>.
- L. Minimum Efficiency AFUE: <Insert number> percent.
- M. Minimum Thermal Efficiency: <Insert number> percent.
- N. Minimum Combustion Efficiency: <Insert number> percent.
- O. Fuel-to-[Steam] [Water] Efficiency: <Insert number> percent.
- P. Number of Passes: [One] [Two] <Insert number>.
- Q. Gas Input: <Insert MBh (kW)>.
- R. Gas Input Flow: <Insert cfh (mL/s)>.
- S. Gas Pressure: <Insert psig (kPa)>.
- T. Oil Input: <Insert MBh (kW)>.

- U. Oil Input Flow: <Insert **gph** (**mL/s**)>.
- V. Output Capacity: <Insert **MBh** (**kW**)>.
- W. Tankless Water Heater:
 - 1. Design Water Flow: <Insert **gpm** (**L/s**)>.
 - 2. Design Pressure Drop: <Insert **psig** (**kPa**)>.
 - 3. Entering-Water Temperature: <Insert **deg F** (**deg C**)>.
 - 4. Leaving-Water Temperature: <Insert **deg F** (**deg C**)>.
- X. Burner Blower:
 - 1. Motor Horsepower: <Insert **number**> hp.
- Y. Electrical Characteristics:
 - 1. Volts: [**115**] [**208**] [**230**] [**460**] <Insert **number**> V.
 - 2. Phase: [**Single**] [**Three**].
 - 3. Hertz: [**50**] [**60**] <Insert **number**> hz.
 - 4. Full-Load Amperes: <Insert **number**> A.
 - 5. Minimum Circuit Ampacity: <Insert **number**> A.
 - 6. Maximum Overcurrent Protection: <Insert **number**> A.
- Z. Sound (decibels, A weighted): <Insert **number**> dB.

2.7 SOURCE QUALITY CONTROL

- A. Test and inspect factory-assembled boilers, before shipping, according to 2010 ASME Boiler and Pressure Vessel Code.
- B. Burner and Hydrostatic Test:
 - 1. Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve performance requirements indicated.
 - 2. Perform hydrostatic test of pressure vessel, piping, and trim of assembled boiler.
- C. Witness Testing:
 - 1. Allow Owner access to witness source quality-control testing of boilers.
 - 2. Notify [**Architect**] [**Owner**] [**15**] <Insert **number**> days in advance of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Before boiler installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and flue; piping; controls; and electrical connections to verify actual locations, sizes, and other conditions affecting boiler performance, maintenance, and operations.
 - 1. Boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for flue, piping, controls, and electrical connections.
- B. Examine areas where boilers will be installed for suitable conditions.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 BOILER INSTALLATION

- A. Coordinate size and location of bases. Cast anchor-bolt inserts into concrete bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
- B. Equipment Mounting:
 - 1. Install boilers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in [Section 033000 "Cast-in-Place Concrete."] [Section 033053 "Miscellaneous Cast-in-Place Concrete."]
 - 2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- C. Install gas-fired boilers according to NFPA 54.
- D. Install oil-fired boilers according to NFPA 31.
- E. Assemble boiler tubes in sequence and seal each tube joint.
- F. Assemble and install boiler trim, components, and accessories that are not factory installed.
- G. Install control and electrical devices furnished with boiler that are not factory mounted.
- H. Install control and power wiring to field-mounted control and electrical devices furnished with boiler that are not factory installed.
- I. Perform boil-out and cleaning procedures according to manufacturer's written instructions after completion of hydrostatic testing and before performing other field tests.[**Boiler manufacturer's factory-authorized representative shall witness boil-out and cleaning procedures.**] Following boil-out and cleaning procedures, boiler shall be washed and flushed until water leaving boiler is clear.
- J. Protect boiler fireside and waterside from corrosion.

1. Before boiler is filled with water, protect by dry storage method recommended by boiler manufacturer.
2. After boiler is filled with water, and left not fired for more than [10] <Insert number> days, protect by wet storage method recommended by boiler manufacturer.
3. Chemical Treatment: Quality of water in boilers shall be maintained by a professional water-treatment organization that shall provide on-site supervision to maintain the required water quality during periods of boiler storage as well as during operating, standby, and test conditions. Refer to <Insert applicable Section number and title> for additional requirements.

3.3 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to boiler(s), allow space for service and maintenance.
- C. Connect gas piping to boiler gas-train inlet with dirt leg, shutoff valve, and union or flange. Piping shall be at least full size of gas-train connection. Provide a reducer if required.
- D. Connect oil piping to oil-train connection with dirt leg, shutoff valve, and union. Piping shall be at least full size of oil-train connection. Provide a reducer if required. Provide drain valve with threaded plug at piping low point.
- E. Connect hot-water piping to supply- and return-boiler connections with shutoff valve and union or flange at each connection.
- F. Connect steam and condensate piping to supply-, return-, and blowdown-boiler connections with union or flange at each connection. Provide each connection with shutoff valve if shutoff valves are not factory furnished with boiler trim. **[Provide check valves in blowdown piping of each boiler that connects multiple boilers.]**
- G. Install piping from safety relief valves to nearest floor drain.
- H. Install piping from safety valves and drip-pan elbows. Extend piping from safety valves and terminate to vent outdoors. Extend piping from drip-pan elbow drain to nearest floor drain.
- I. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.
- J. Hot equipment drains connected to sanitary drainage system shall be cooled before discharging into the system if required to comply with more stringent of governing code requirements and requirements indicated.
 1. Provide a temperature-controlled nonpotable domestic cold water source to cool hot equipment drains to deliver a discharge temperature of <Insert temperature>.
- K. Connect chemical-treatment piping to each boiler chemical-treatment connection with check valve and isolation valve.

3.4 FLUE CONNECTIONS

A. Boiler Flue Venting:

1. Install venting kit and combustion-air intake.
2. Connect full size to boiler connections. Comply with requirements in Section 235123 "Gas Vents."

B. Connect breeching to full size of boiler outlet. Comply with requirements in [Section 235116 "Fabricated Breechings and Accessories"] [and] [Section 235133 "Insulated Sectional Chimneys"] for venting materials.

C. Install flue-gas recirculation duct from vent to burner if not factory furnished and installed. Comply with requirements in Section 235116 "Fabricated Breechings and Accessories" for recirculation duct materials.

D. Install easily accessible test ports for field testing of flue gas from each boiler.

3.5 ELECTRICAL POWER CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

3.6 CONTROLS CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between boilers and other equipment to interlock operation as required, to provide a complete and functioning system.

C. Connect control wiring between boiler control interface and [DDC control system] <Insert system description> for remote monitoring and control of boilers. Comply with requirements in [Section 230923 "Direct Digital Control (DDC) System for HVAC"] <Insert Section number and title>.

3.7 NETWORK AND PHONE CONNECTIONS

A. Connect LAN/WAN network cable to boiler controls to provide connectivity for remote monitoring through integrated boiler control system.

B. Connect phone system cable to boiler controls to provide connectivity for remote monitoring and alarm notification through integrated boiler control system.

3.8 FIELD QUALITY CONTROL

- A. Testing Agency: **[Owner will engage]** **[Engage]** a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections **[with the assistance of a factory-authorized service representative]**:
 - 1. Perform installation and startup checks according to manufacturer's written instructions.
 - 2. Hydrostatic Leak Test: Repair leaks and retest until no leaks exist.
 - 3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - a. Burner Test: Adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency.
 - b. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level, and **[water temperature]** **[steam pressure]**.
 - c. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- D. Boiler will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.
- F. Occupancy Adjustments: When requested within **[12 months of date of Substantial Completion]** **<Insert time period>**, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to **[two]** **<Insert number>** visits to Project during other-than-normal occupancy hours for this purpose.
- G. Performance Tests:
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
 - 2. Boilers shall comply with performance requirements indicated, as determined by field-performance tests. Adjust, modify, or replace equipment in order to comply.
 - 3. Perform field-performance tests to determine the capacity and efficiency of the boilers.
 - a. For dual-fuel boilers, perform tests for each fuel.
 - b. Test for full capacity.
 - c. Test for boiler efficiency at **[low fire, 10, 20, 30, 40, 50, 60, 70, 80, 90, and high fire (100)]** **<Insert range>** percent of full capacity. Determine and document efficiency at each test point.

4. Test each safety valve. Record pressure at valve blowdown and reset. Test valve(s) with boiler operating at full capacity to ensure valve has capacity to prevent further rise in pressure.
5. For boilers equipped with automatic oxygen trim control, conduct tests with automatic oxygen trim control on manual at zero trim and record performance. Repeat tests with automatic oxygen trim control under automatic control and record performance.
6. Repeat tests until results comply with requirements indicated.
7. Provide measurement and analysis equipment required to determine performance.
8. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are inadequate.
9. Notify **[Architect] [Owner] [20] <Insert number>** days in advance of test dates.
10. Document test results in a report and submit with informational submittals.

3.9 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train] [Train]** Owner's maintenance personnel to adjust, operate, and maintain boilers.**[Video training sessions and provide electronic copy of video to Owner.]** Refer to Section 017900 "Demonstration and Training."

END OF SECTION 235233