SECTION 235216 - STAINLESS STEEL FIRETUBE CONDENSING BOILERS

1. GENERAL
   1. SUMMARY
      1. This Section includes packaged, factory-fabricated and -assembled, gas-fired, firetube stainless steel ultra-high efficiency condensing boilers, trim and accessories for generating hot water.
   2. REFERENCES
      1. ASME Section IV
      2. CAN-1.3.1-77, Industrial and Commercial Gas Fired Packaged Boilers
      3. CSD-1, Controls and Safety Devices
      4. XL GAPS
      5. NEC, National Electric Code
      6. CSA 4.9, ANSI Z21.13
      7. AHRI, BTS-2000
      8. ASHRAE 90.1
   3. SUBMITTALS
      1. Product Data: Include performance data, operating characteristics, technical product data, rated capacities of selected model, weights (shipping, installed and operating), installation and start-up instructions, and furnished accessory information.
      2. Shop Drawings: For boiler, standard boiler trim and accessories.
         1. End Assembly Drawing: Detail overall dimensions, connection sizes, connection locations, and clearance requirements.
         2. Wiring Diagrams: Detail electrical requirements for the boiler including ladder type wiring diagrams for power, interlock and control wiring. Clearly differentiate between portions of wiring that are factory installed and portions to be field installed.
      3. Certificate of Product Rating: Submit AHRI Certificate indicating Thermal Efficiency, Combustion Efficiency, Materials of Construction, Input, and Gross Output conform to the design basis.
      4. Thermal efficiency curves: Submit thermal efficiency curves between and including minimum and maximum rated capacities, for return water temperatures ranging from 80°F to 180°F.
      5. Water side pressure drop curve.
      6. Flue gas temperature curves: Submit flue gas temperature curves for minimum and maximum boiler capacity, for return water temperatures ranging from 80°F to 160°F.
         1. If submitted flue gas temperatures or excess O2% levels, minimum or maximum inputs are different from that of the basis of design manufacturer and model, the manufacturer shall be responsible for draft calculations and potential costs associated with reselection of the flue gas exhaust vent system.
      7. Source quality-control test reports.
      8. Field quality-control test reports: Start-up by a factory authorized service company.
      9. Operation and Maintenance Data: Data to be included in Installation and Operation Manual.
      10. Warranty: Standard warranty specified in this Section.
   4. QUALITY ASSURANCE
      1. Manufacturer Qualifications: Firms regularly engaged in the manufacture of condensing hydronic boilers with welded steel pressure vessels, whose products have been in satisfactory use in service for not less than twenty-five (25) years. The manufacturer must be headquartered in North America and manufacture pressure vessels in an ASME-certified facility wholly owned by the manufacturer. The specifying engineer, contractor and end customer must have the option to visit the factory to witness test fire and other relevant procedures.
      2. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
      3. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code, Section IV “Heating Boilers”, for a maximum allowable working pressure of 160 PSIG.
      4. CSD-1 Compliance: The boiler shall comply with ASME Controls and Safety Devices for Automatically Fired Boilers (CSD-1).
      5. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to “Gas and Oil Fired Boilers - Minimum Efficiency Requirements.”
      6. UL Compliance: Boilers must be tested for compliance with UL 795, “Standard for Commercial-Industrial Gas Heating Equipment.” Boilers shall be listed and labeled by ETL.
      7. AHRI Compliance: Boilers shall be tested and rated according to the BTS-2000 test standard and verified by AHRI.
      8. The equipment shall be of the type, design, and size that the manufacturer currently offers for sale and appears in the manufacturer’s current catalog.
      9. The equipment shall fit within the allocated space, leaving ample allowance for maintenance and inspection.
      10. The equipment shall be new and fabricated from new materials. The equipment shall be free from defects in materials and workmanship.
      11. In order to provide unit responsibility for the specified capacities, efficiencies, and performance, the boiler manufacturer shall certify in writing that the equipment being submitted shall perform as specified.
   5. COORDINATION
      1. Mechanical contractor shall coordinate the size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete reinforcement and formwork requirements are specified in Division 03.
   6. WARRANTY
      1. Standard Warranty: Manufacturer’s standard form in which manufacturer agrees to repair or replace components of boilers that fail in materials or workmanship within specified warranty period provided the boiler is installed, controlled, operated and maintained in accordance with the Installation, Operation and Maintenance Manual.
         1. Warranty Period for the Pressure Vessel and Heat Exchanger: The boiler manufacturer shall warranty against failure due to:
            1. Flue gas condensate corrosion, and/or defective material or workmanship for a period of ten (10) years, non-prorated, from the date of shipment from the factory.
            2. Thermal shock for the lifetime of the boiler.
         2. Warranty Period for the Burner: The boiler manufacturer shall warranty the mesh burner head against defective material or workmanship for a period of five (5) years, non-prorated, from the date of shipment from the factory.
         3. Warranty Period for all other components: The boiler manufacturer will repair or replace any part of the boiler that is found to be defective in workmanship or material for a period of two (2) years, non-prorated, from the date of shipment from the factory.
2. PRODUCTS
   1. MANUFACTURERS
      1. This specification is based on the Endura+ series boilers as manufactured by Fulton Heating Solutions, Inc. Equivalent units and manufacturers must meet all performance criteria, and will be considered upon prior approval.
      2. Basis-of-Design Product: Subject to compliance with requirements, provide Fulton Heating Solutions, Inc.
         1. Endura+ model **[EDR+2500] [EDR+3000] [EDR+4000] [EDR+5000] [EDR+6000]** stainless steel firetube condensing boiler.
            1. Alternate boilers must equal or exceed all aspects of this specification in its entirety throughout. Boilers seeking an approval shall provide documentation that supports this requirement.
      3. The boiler manufacturer shall have the capability to construct an engineered hydronic system, skid mounted, for the above referenced boilers incorporating single point electrical, supply water, return water, fresh water make up, fuel, and drain. The boiler manufacturer shall have the engineering capabilities for all aspects of the mechanical, electrical and control design of the skidded system.
   2. CONSTRUCTION
      1. Description: Factory-fabricated, -assembled, and -pressure tested, stainless steel firetube condensing boiler with heat exchanger sealed pressure tight, built on a steel base; including flue gas vent; combustion air intake, water supply, water return, condensate drain, and controls. The boiler, burner and controls shall be completely factory assembled as a self-contained unit. Each boiler shall be neatly finished, thoroughly tested, and properly packaged for shipping. The boiler shall be suitable for closed-loop water hydronic heating service.
      2. Heat Exchanger: The heat exchanger is defined as the surfaces of the pressure vessel where combustion gases transfer heat to the hydronic heating fluid.
         1. Material: The heat exchanger furnace, tubesheet(s), and firetubes shall be constructed of duplex or ferritic stainless steel alloys.
            1. For long term durability, heat exchanger material of construction must have a minimum 0.2% Yield Strength of 30 ksi. Weaker materials of construction with reduced yield strength are not accepted. Boilers seeking approval must provide documentation supporting this requirement or will be rejected.
            2. The nickel content in weight percent shall not exceed 6.5%. A nickel content between 7 to 20% is highly susceptible to Stress Corrosion Cracking (SCC), a mode of cracking failure instigated without warning which can be catastrophic in pressurized equipment. Austenitic stainless steels including 316(L) and 304(L) are most prone to this mode of failure and are not accepted.
            3. Heat exchangers constructed of austenitic stainless steels, cast aluminum, mild steel, cast iron or copper materials are not accepted.
         2. The boiler shall be a single-pass firetube design, such that all combustion chamber components are within water-backed areas. Watertube boilers will not be accepted.
         3. Furnace to tube connections shall be constructed with low weld intensity, a tube to tube minimum spacing of 2 tube diameters center to center, minimum 1 tube diameter tube to tube ligament, and shall not contain any overlapping welds.
         4. Heat transfer capability shall be maximized via the use of corrugated firetubes. The corrugation process shall not remove any material from the tubes. Finned, twisted tape, or coil type tube inserts negatively impact ease of maintenance and will not be accepted.
         5. The boiler shall compensate for heat exchanger thermal expansion using a stress relief deflection element external to the pressure vessel shell. The deflection element shall act to protect the boiler tubes and tubesheets from exposure to longitudinal thermal expansion stresses. The deflection element shall not be in contact with flue gases.
            1. Designs using the tubes, tubesheets, or furnace components to compensate for thermal expansion require cutting, welding, tube repair, or complete heat exchanger replacement in the event of deflection element failure and are not accepted.
            2. Designs which do not compensate for thermal expansion stresses are not accepted.
         6. Tubesheet to tube weld stresses while the boiler is in operation shall never exceed 1.0 ksi.
      3. Exhaust manifold shall be minimum 0.5” thick stainless steel, ASME designation SA-351 CF3M, and shall be a water-backed design to enhance heat transfer. Dry-back style flue gas condensate collection pan exhaust manifolds are not accepted.
      4. Pressure Vessel: Design and construction shall be in accordance with Section IV of the ASME Code for heating boilers.
         1. The shell shall be minimum 0.375” thick steel, SA-53B ERW.
         2. The top head shall be a minimum 0.50” thick steel, SA-790 or SA-516 Grade 70.
         3. The pressure vessel shall be a counter-flow design with internal water-baffling plates.
         4. The boiler return and supply water connections shall be 150# ANSI flanged. The water connections shall not be designed to support an external structural load from the piping system.
         5. The water volume of the boiler shall not be less than 80 gallons.
         6. The maximum water pressure drop across the boiler inlet and outlet connections shall not exceed **[3.0 PSID at 235 GPM for 2,500 MBTU/hr boiler] [5.0 PSID at 289 GPM for 3,000 MBTU/hr boiler] [2.8 PSID at 383 GPM for 4,000 MBTU/hr boiler] [4.1 PSID at 472 GPM for 5,000 MBTU/hr boiler] [6.0 PSID at 570 GPM for 6,000 MBTU/hr boiler]**.
      5. Fuel/Air Mixture Combustion System: Air and gas pre-mix on the suction side of the fan.
         1. A Flame-by-Wire™ or equivalent electronic combustion control system shall be provided to empower technicians to accurately dial-in positions electronically. The system shall feature O2 Compensation™ or equivalent to continuously tune the burner air-fuel ratio in real time, automatically adjusting for changes in seasonality to maximize combustion efficiency and condensate production for greater energy savings and reduced emissions. Pneumatic (“negative regulation”, “zero governor”) type systems offer far less precision and are not capable of independent air and gas control and are not accepted.
         2. The air and gas tolerance shall be no greater than +/- 0.2° to allow for much more precise control of air-fuel ratio compared to linkages that may slip, or pneumatic gas valves which drift over time and have difficulty handling environmental and installation fluctuations.
            1. Combustion air flow shall be controlled by fan speed and a servo-motor actuated butterfly valve. Fuel flow shall be controlled by a servo-motor actuated butterfly valve.
         3. Closed-loop oxygen sensor shall sample combustion chamber gases in conjunction with PURE Control™ algorithms with open-loop instrumentation and be used for autonomous fuel/air ratio tuning without requiring manual input. O2 feedback or monitoring-only systems cannot adjust for operation variability and are not accepted.
      6. Burner: Standard natural gas, forced draft, woven fiber mesh design.
         1. Turndown: Shall be no less than **[EDR+2500: 12.5:1] [EDR+3000: 15:1] [EDR+4000: 10:1] [EDR+5000: 12.5:1] [EDR+6000: 15:1]**.
         2. Excess Air: The burner shall be capable of operating at no greater than 8.0% excess O2 over the entire modulation range to maximize seasonal combustion and thermal efficiencies.
         3. NOx Emissions: When operating on natural gas, the burner shall maintain a level of <20 ppm over the complete combustion range at a 3% O2 correction. The natural gas burner shall be configurable down to <7 ppm NOx when operating on 460/3/60 electrical service.
         4. Alternative Renewable Fuels: The burner shall be hydrogen-ready for blends of up to 20% hydrogen and 80% natural gas, including fossil-free renewable natural gas (RNG). To ensure future-proof service, those seeking an approval shall provide documentation proving successful laboratory tests on Hydrogen blends.
         5. **[Optional Equipment]** A dual-gas manifold kit shall be supplied for combination natural gas and propane operation using the same combustion control system and burner for both fuels. Burners which require conversion or reconfiguration to switch fuel types will not be accepted. The flame safeguard shall have two fuel profiles, flame safeguards with a single fuel profile cannot be optimized for both fuels and will not be accepted.
      7. Blower: Variable speed centrifugal fan to operate during each burner firing sequence and to pre-purge and post-purge the combustion chamber.
         1. Motor: Totally enclosed fan-cooled premium efficiency AC motor, Class H insulation, variable speed capable with sealed bearings.
            1. Variable speed drive: IP20 housing, 0-400Hz frequency output capability, overload capacity of 150% for 60 seconds and 200% for 3 seconds, shall fully modulate fan speed according to burner input requirements.
         2. Motor Alternate: Closed-loop brushless DC variable speed motor with hall effect sensor feedback; internal electronic commutation controller with built in speed control and protection features; long life, sealed, ball bearing with high temperature grease.
      8. Main Fuel Train:
         1. A factory mounted fuel train shall be supplied. The fuel train shall be fully assembled and enclosed within the boiler cabinet, complete with factory mounted and wired high and low gas pressure switches in compliance with CSD-1.
      9. Ignition: Direct spark ignition with transformer. A UV scanner shall be utilized to ensure precise communication of flame status back to the flame programmer. Flame rods are not accepted.
      10. Boiler Enclosure:
          1. Cabinet: Jacketed steel enclosure with left hinged full height front access door, fully removable latching access panels, mounted on a steel skid with steel plate decking.
          2. Control Enclosure: NEMA 250, Type 1.
          3. Finish: Cabinet shall be powder coated, pressure vessel assembly shall be painted.
          4. Combustion Air: Factory mounted air filter directly coupled to the blower inlet.
      11. Rigging and Placement: The boiler shall include lifting eyes and fork hole accessibility for rigging.
      12. Characteristics and Capacities:
          1. Standard capacities shall be based on 100% water.
          2. Minimum Design Water Pressure Rating: 160 psig.
          3. Minimum Return Water Temperature: No minimum temperature requirements.
          4. Maximum Allowable Water Temperature (ASME): 210°F.
          5. Minimum Water Flow Rate: **[EDR+2500/3000: 25 gpm] [EDR+4000/5000/6000: 75 gpm]**.
          6. Maximum Delta-T: 100°F
          7. Maximum Allowable Operating Setpoint: 200°F
          8. Jacket Losses: External convection and radiation heat losses to the boiler room from the boiler shall comply with IAW ASHRAE 103-2007, and shall not exceed 0.2% of the rated boiler input at maximum capacity.
      13. Flow switches, dedicated circulator pumps, or primary-secondary arrangements shall not be required to protect the boiler from thermal shock. Boilers requiring the use of flow switches or primary-secondary piping arrangements will not be accepted.
      14. The dimensions of the boiler from where service clearances are measured shall not be more than (Height x Width x Depth) **[EDR+2500/3000: 80” x 30” x 73”] [EDR+4000/5000/6000: 79” x 34” x 117”]**.
      15. The equipment shall be in strict compliance with the requirements of this specification and shall be the manufacturer’s standard commercial product unless specified otherwise. Additional equipment features, details, accessories, etc. which are not specifically identified but which are a part of the manufacturer’s standard commercial product, shall be included in the equipment being furnished.
   3. TRIM
      1. Safety Relief Valve: ASME rated **[60] [100] [125] [160]** psig.
      2. Pressure and Temperature Gauge: Minimum 3-1/2” diameter, combination pressure and temperature gauge.
      3. Flue Gas Condensate Drain Trap: A flue gas condensate drain trap shall be provided to prevent positive pressure exhaust gases from entering the boiler room.
      4. **[Optional Equipment]** Flue Gas Condensate Neutralization: pH neutralization shall be provided.
   4. CONTROLS
      1. The boiler electrical control panel shall include the following devices and features:
         1. 7” color touch screen control display factory mounted on the front cabinet panel door.
            1. The control display shall serve as a user interface for programming parameters, boiler control and monitoring; and shall feature a screen saver, boiler status, configuration, history and diagnostics.
         2. Controls Transformers: 120VAC, 24 VDC, 12 VDC.
         3. Flame safeguard control with 9 combustion fuel/air load profile points.
         4. All standard controls shall be factory mounted and wired according to UL requirements.
      2. Burner Operating Controls: To maintain safe operating conditions, factory mounted and wired burner safety controls limit burner operation:
         1. High Limit: A manual reset mechanical Aquastat device shall stop the burner if operating conditions rise above maximum boiler design temperature.
         2. Low-Water Cut Off: Electronic probe type mounted in the pressure vessel shall prevent burner operation on low water alarm.
         3. Air Safety Switch: Prevent operation unless sufficient combustion air is proven.
         4. Blocked Exhaust: Prevent operation in the event of a blocked flue gas exhaust stack.
      3. O2 Compensation: To maximize efficiency throughout seasonality, factory mounted and wired.
         1. A wide band Oxygen sensor shall be factory mounted and measure the Oxygen level present in combustion byproducts during run. The current Oxygen level shall be displayed to the user. The Oxygen sensor minimum requirements shall be:
            1. Lambda range: λ = 0.65 to ∞
            2. Lambda accuracy: ±0.008 @ λ=1.00; ±0.01 @ λ=0.80; ±0.05 @ λ=1.70
         2. The O2 Compensation system shall utilize a combination open-loop and closed-loop control system to tune the air/fuel ratio during operation, optimizing combustion reliability, flame stability, combustion efficiency, and the dewpoint temperature for formation of flue gas condensate.
         3. Boilers listed as an alternate to the Basis of Design that do not include a closed-loop O2 Compensation control system in compliance with this specification shall be required to provide and commission a Siemens LMV52 Burner Management System with the QGO20 Oxygen Sensor, PLL52.110A100 O2 Trim Module, and associated installation parts.
      4. Boiler Operating Controls and Features:
         1. Inlet Water Temperature Monitoring.
         2. Combustion Air Temperature Monitoring.
         3. Flue Gas Exhaust Temperature Monitoring: Sensor probe shall be stainless steel.
         4. Proportional Integral Derivative (PID) temperature load control capability for hydronic and domestic hot water in standalone or lead/lag operation.
         5. Operating temperature sensor for automatic start and stop.
            1. The temperature sensor shall have tolerance according to IEC 60751
         6. Time of day display.
         7. Customizable boiler name display.
         8. Two customizable boiler interlock terminals displayed.
         9. Alarm history for a minimum 100 most recent alarms including status at time of lockout.
         10. Administrative password protection options.
         11. Indirect domestic hot water priority.
         12. **[Optional:]** Outdoor air temperature (OAT) reset controls with warm weather shutdown:
             1. OAT reset shall automatically adjust the setpoint according to changes in the outdoor temperature, and disable the boilers above a warm weather shutdown temperature.
             2. The boiler manufacturer shall provide an OAT sensor.
             3. The temperature sensor shall be field installed in an outdoor area not exposed to direct sunlight or the exhaust of other mechanical equipment, and wired the boiler controller.
             4. The control shall be field programmed with the outdoor reset schedule.
         13. Variable Speed System (Secondary) Pump Control:
             1. When installed in a variable primary flow configuration, the boiler controller shall provide the capability to control two variable speed hydronic heating pumps. One pump shall be duty, and one standby.
             2. The duty system pump shall be enabled upon the outdoor air temperature dropping below the warm weather shutdown temperature. Pumps shall be automatically rotated.
             3. Variable speed signal shall be provided to modulate pump speed according to hydronic heating loop Delta-T. A user selectable parameter allows for Delta-P in place of Delta-T.
         14. Motorized isolation valve control:
             1. Upon heat demand for the boiler, the control shall provide an enable/open signal.
             2. After the burner is disabled and upon the heat exchanger delta-T dropping to a user programmable delta-T, the signal will be disabled.

Boilers which utilize only a time delay close as the only means of valve actuation are unable to optimize for residual heat, and will not be accepted.

* + - * 1. In variable primary arrangements, the control shall hold the lead boiler isolation valve open at all times.
    1. Lead/Lag Control of Modular (Multiple) Boiler Plants: Lead/Lag capabilities shall be integral to the boiler controller for up to 10 boilers installed in the same hydronic loop and shall not require an external panel.
       1. The boiler manufacturer shall provide a supply water header temperature sensor.
          1. The temperature sensor shall have tolerance according to IEC 60751, field installed in the common supply water piping.
       2. Lead/lag operation shall not require a master boiler or external control panel. Field wired sensors or communication may be connected to any boiler in the lead/lag sequence.
       3. The boilers shall communicate with each other via a private Ethernet/IP addressed network.
          1. Field wiring between boilers shall be shielded Cat5e or Cat6 Ethernet cable.
          2. In the event a communication cable becomes damaged or interrupted, communication shall be lost with only one boiler and not the entire lead/lag operation. Daisy chain style wiring lacks this redundancy and shall not be accepted.
       4. Sequence of Operation:
          1. Upon loop temperature dropping below start point, the lead boiler shall be enabled at low fire and shall modulate according to the heating demand.
          2. As lag boiler stages are enabled according to heating demand, burners shall return to low fire. Boilers shall modulate in parallel as a cohesive unit according to heating demand.
          3. When all boilers are active they shall be released to modulate in parallel up to full fire according to the heating demand.
          4. As heating demand decreases, the sequence shall operate in reverse.
          5. Rotation of the lead and subsequent lag boilers shall be automatic.
    2. Building Automation System Interface: Hardware and software to enable building automation system (BAS) to monitor, control, and display boiler status and alarms.
       1. Hardwired Contacts:
          1. Monitoring: Boiler Status, Burner Demand, General Alarm.
          2. Control with Factory Installed Jumper: Safety Interlock for External Device, Remote Enable, Emergency Stop (E-Stop).
          3. Remote Setpoint Signal: 4-20 mA or 0-10 VDC.
       2. Communication Protocol: A Modbus communication interface with BAS shall enable BAS operator to remotely enable and monitor the boiler plant from an operator workstation.
          1. **[Optional Device:]** A BACnet MSTP and IP protocol communication gateway shall be provided. The BACnet gateway is field installed on a boiler. Additional boilers in the lead/lag system shall not require a dedicated BACnet gateway for the BAS to monitor status. A communication point mapping list shall be provided.
          2. **[Optional Device:]** A LonWorks protocol communication gateway shall be provided. The LonWorks gateway is field installed on a boiler. Additional boilers in the lead/lag system shall not require a dedicated LonWorks gateway for the BAS to monitor status. A communication point mapping list shall be provided.
  1. ELECTRICAL POWER
     1. Single-Point Field Power Connection: Factory-installed and factory-wired switches, transformers, control and safety devices and other devices shall provide a single-point field power connection to the boiler.
     2. Electrical Characteristics:
        1. Voltage: 460 V.
        2. Phase: Three.
        3. Frequency: 60 Hz.
  2. VENTING
     1. The boiler shall be capable of operating with a stack effect not exceeding -0.10” W.C. and a combined air intake and exhaust venting pressure drop not exceeding **[EDR+2500/3000: +1.50” W.C.] [EDR+4000/5000/6000: +1.0” W.C.]**.
     2. Combustion Air Intake: It shall be acceptable to either direct vent the boiler using sealed combustion by drawing combustion air in from the outdoors or by drawing air from the mechanical space itself.
        1. Sealed Combustion: Schedule 40 PVC pipe or smooth-walled galvanized steel, vent termination with 1/2” x 1/2” mesh bird screen.
        2. Mechanical Space: Adequate combustion air and ventilation shall be supplied to the boiler room in accordance with boiler manufacturer requirements and local codes.
     3. Flue Gas Exhaust: The flue gas exhaust stack shall be AL 29-4C or 316L stainless steel, listed and labeled to UL-1738 / C-UL S636 for use with Category II/IV appliances, guaranteed appropriate for the application by the manufacturer and supplier of the venting.
     4. Common Exhaust Vents: The draft system shall be designed to prevent the backflow of exhaust gases through idle boilers. The common boiler vent shall not be combined with any other appliance.
     5. Condensate drain piping must be galvanized, stainless steel, or Schedule 40 CPVC. Copper, carbon steel, or PVC pipe materials are not accepted.
  3. SOURCE QUALITY CONTROL
     1. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.
     2. Each boiler shall be installed and operated in a functioning hydronic system, inclusive of venting, as part of the manufacturing process. A factory test fire report corresponding to the boiler configuration shall be included with each boiler.

1. EXECUTION
   1. EXAMINATION
      1. Before boiler installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting boiler performance, maintenance, and operations.
         1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.
      2. Examine mechanical spaces for suitable conditions where boilers will be installed.
      3. Proceed with installation only after satisfactory conditions have been verified.
   2. BOILER INSTALLATION
      1. Install boilers level on concrete base, minimum 4 inches high. Concrete base is specified in Division 23 Section “Common Work Results for HVAC,” and concrete materials and installation requirements are specified in Division 03.
      2. Install gas-fired boilers according to NFPA 54. Equipment and materials shall be installed in an approved manner and in accordance with the boiler manufacturer’s installation requirements.
      3. Assemble and install boiler trim.
      4. Install electrical devices furnished with the boiler but not specified to be factory mounted.
      5. Install control wiring to field-mounted electrical devices.
   3. CONNECTIONS
      1. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
      2. 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.
      3. Connect gas piping to boiler gas train inlet with isolation valve and union. Piping shall be at least full size of gas train connection. Provide a reducer if required.
      4. Connect hot water supply and return water connections with shutoff valve and union or flange at each connection.
      5. Install piping from safety relief valves to the nearest floor drain or local equivalent approved by local code.
      6. Install piping from flue gas condensate drain connection to the condensate drain trap and to the nearest floor drain.
      7. Boiler Venting:
         1. Install flue venting and combustion air-intake.
         2. Connect to boiler connections, flue size and type as recommended by the manufacturer.
      8. Ground equipment according to Division 26 Section “Grounding and Bonding for Electrical Systems.”
      9. Connect wiring according to Division 26 Section “Low-Voltage Electrical Power Conductors and Cables.”
   4. FIELD QUALITY CONTROL
      1. Perform tests and inspections and prepare test reports.
         1. After boiler installation is completed, the manufacturer shall provide the services of a field representative to inspect components, assemblies, and equipment installations, including connections and provide startup of the boiler and training to the operator.
         2. Arrange with National Board of Boiler and Pressure Vessel Inspectors for inspection of boilers and piping. Obtain certification for completed boiler units, deliver to Owner, and obtain receipt.
      2. Tests and inspections:
         1. Perform installation and startup checks according to manufacturer’s written instructions.
         2. Leak Test: Hydrostatic 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.
            1. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level and water temperature.
      3. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 235216