SECTION 235216 - DUPLEX STAINLESS STEEL FIRETUBE CONDENSING BOILERS

1. GENERAL
   1. SUMMARY
      1. This Section includes packaged, factory-fabricated and -assembled, gas-fired, firetube duplex alloy 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. UL-795 7th Edition
      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, 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 reselection of the flue gas exhaust 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 privately owned and headquartered in North America. The specifying engineer, contractor and end customer must have the option to visit the factory during the manufacture of the boilers and be able to witness test fire and other relevant procedures.
      2. Aftermarket Support and Service: The manufacturer shall have a factory authorized service training program, where boiler technicians can attend a training class and obtain certification to perform start-up, maintenance and basic troubleshooting specific to the product line.
      3. 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.
      4. 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.
      5. CSD-1 Compliance: The boiler shall comply with ASME Controls and Safety Devices for Automatically Fired Boilers (CSD-1).
      6. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to “Gas and Oil Fired Boilers - Minimum Efficiency Requirements.”
      7. UL Compliance: Boilers must be tested for compliance with UL 795, “Commercial-Industrial Gas Heating Equipment.” Boilers shall be listed and labeled by ETL.
      8. AHRI Compliance: Boilers shall be tested and rated according to the BTS-2000 test standard and verified by AHRI.
      9. NOx Emissions Compliance: Boiler shall be tested for compliance with SCAQMD and TCEQ.
      10. 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.
      11. The equipment shall fit within the allocated space, leaving ample allowance for maintenance and inspection.
      12. The equipment shall be new and fabricated from new materials. The equipment shall be free from defects in materials and workmanship.
      13. All units of the same classification shall be identical to the extent necessary to ensure interchangeability of parts, assemblies, accessories, and spare parts wherever possible.
      14. 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 featuring PURE Control™ 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-750] [EDR-1000] [EDR-1500] [EDR-2000]** duplex 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 aspects of the skid mounted system.
   2. CONSTRUCTION
      1. Description: Factory-fabricated, -assembled, and -pressure tested, duplex stainless steel firetube condensing boiler with heat exchanger sealed pressure tight, built on a steel base; including flue gas vent; combustion air intake connections, 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. Closed-loop water heating service only.
      2. Heat Exchanger: The heat exchanger is defined as the surfaces of the pressure vessel where flue gases transfer sensible and latent heat to the hydronic fluid. The heat exchanger shall be a three-pass firetube design constructed using only duplex alloys of stainless steel.
         1. The boiler shall be a firetube design, such that all combustion chamber components are within water-backed areas. Watertube boilers will not be accepted.
         2. Furnace: First pass of the combustion chamber shall be constructed of duplex alloy stainless steel with a minimum wall thickness of 0.25” and a minimum bottom head thickness of 0.625”.
         3. Firetubes: Second and third passes of the combustion chamber shall be constructed of duplex alloys of stainless steel having a minimum wall thickness of **[EDR-750/1000: 0.083”] [EDR-1500/2000: 0.109”]**.
         4. Furnace to tube connections shall be constructed with low weld intensity, a tube to tube minimum spacing of 2” center to center, minimum 5/8” tube to tube ligament, and shall not contain any overlapping welds.
         5. Heat exchange capability shall be maximized within the heat exchanger via the use of corrugated firetube technology. The corrugation process shall not remove any material from the tubes. Aluminum heat transfer enhancements are dissimilar metals and are unacceptable.
         6. Material: The heat exchanger shall have the following material characteristics and properties:
            1. The metallic crystalline lattice microstructure shall contain approximately equal amounts of body center cubic (BCC) and face centered cubic (FCC) structures to offer high resistance to intergranular corrosion.
            2. A minimum Pitting Resistance Equivalent Number (PREN) of 26.
            3. A minimum Yield Strength of 65 ksi at 0.2% plastic strain.
            4. A minimum Ultimate Tensile Strength of 94 ksi.
            5. To minimize stresses caused by uneven expansion and contraction, the Coefficient of Thermal Expansion at 212°F shall not be less than 7.0 in/in °F 10-6 and shall not be greater than 7.5 in/in °F 10-6.
            6. To increase resistance to pitting and crevice corrosion, the Chromium content shall not be less than 21% by mass.
            7. For high mechanical strength, the Nitrogen content shall not be less than 0.17% by mass.
            8. Boilers with heat exchangers constructed of austenitic stainless steels, such as 316L or 304, and ferritic stainless steels, such as 439, are unacceptable.
            9. Boilers with heat exchangers constructed of cast aluminum, mild steel, cast iron or copper finned tube materials are unacceptable.
      3. 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 **[EDR-750/1000: 0.25”] [EDR-1500/2000: 0.3125”]** thick steel, SA-790 or SA-516 Grade 70.
         2. The top head shall be a minimum 0.375” thick steel, SA-790 or SA-516 Grade 70.
         3. The water side of the pressure vessel shall be a counter-flow design with internal water-baffling plates.
         4. The boiler return and supply water connections shall be **[EDR-750/1000: 2” threaded male NPT] [EDR-1500/2000: 4” 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 **[EDR-750/1000: 50 Gallons] [EDR-1500: 104 Gallons] [EDR-2000: 102 Gallons]**.
            1. For boilers with a lower water volume, the boiler manufacturer shall provide a buffer tank and all associated buffer tank ancillaries to make equivalent to the total volume of the design basis.
         6. The maximum water pressure drop across the boiler inlet and outlet connections, shall not exceed **[EDR-750: 0.5 PSID at 75 GPM] [EDR-1000: 0.8 PSID at 100 GPM] [EDR-1500: 0.9 PSID at 150 GPM] [EDR-2000: 1.6 PSID at 200 GPM]**.
      4. 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. PURE Control™ algorithms with open-loop instrumentation shall 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.
      5. Burner: Standard natural gas, forced draft.
         1. Burner Head: Shall be a woven metal fiber premix design.
         2. Excess Air: The burner shall operate at no greater than 8.0% excess O2 over the entire turndown range. Due to significant reductions in combustion efficiency at high levels of excess O2, boilers exceeding 8.0% excess O2 at any operating condition shall not be accepted.
         3. Emissions: When operating on natural gas, the boiler shall maintain a NOx level of <20 ppm, and CO emissions less than 50 ppm, over the complete combustion range at a 3% O2 correction.
         4. Ignition: Automatic direct spark ignition electrode.
         5. 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 approval shall provide documentation proving successful laboratory tests on Hydrogen blends.
      6. Blower: Variable speed, non sparking, hardened aluminum impeller centrifugal fan to operate during each burner firing sequence and to pre-purge and post-purge the combustion chamber.
         1. Motor: 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.
         2. Variable speed blower: Closed loop PWM signal input with tachometer output.
      7. Main Fuel Train:
         1. The boiler shall have a pre-mix combustion system, capable of operating at a minimum 4” W.C. incoming natural gas pressure while simultaneously achieving emissions performance, full modulation, and full rated input capacity. Maximum natural gas pressure allowed to the inlet of the fuel train shall be no less than 28” W.C.
         2. A factory mounted main fuel train shall be supplied. The fuel train shall be fully assembled complete with high and low gas pressure switches, wired, and installed on the boiler and shall comply with CSD-1 code. The fuel train components shall be enclosed within the boiler cabinet.
         3. Standard CSD-1 fuel train shall comply with AXA XL.
      8. Boiler Enclosure:
         1. Sealed Cabinet: Jacketed steel enclosure with left hinged full height front access door, fully removable latching access panels, gasketed seams to maintain sealed combustion, mounted on a steel skid with steel plate decking.
         2. Control Enclosure: NEMA 250, Type 1.
         3. Finish: Internally and externally primed and painted or powder coated.
         4. Combustion Air: Drawn from the inside of the sealed cabinet, preheating the combustion air.
      9. Rigging and Placement: The boiler shall come with lifting eyes and fork hole accessibility for rigging.
      10. Exhaust Manifold: Shall be constructed of stainless steel, with an area for the collection and disposal of flue gas condensate.
      11. Characteristics and Capacities:
          1. Heating Medium: Closed loop hot water with up to 50% propylene or ethylene glycol by volume. Standard capacities shall be based on 100% water.
          2. Design Water Pressure Rating: 160 psig.
          3. Safety Relief Valve Setting: **[60] [100] [125] [160]** psig.
          4. Minimum Return Water Temperature: No minimum temperature required.
          5. Maximum Allowable Water Temperature: 210°F.
          6. Minimum Water Flow Rate: No minimum flow rate required to protect the heat exchanger.
          7. Maximum Water Flow Rate: No maximum flow rate requirement.
          8. Minimum Delta-T: No minimum delta-T required.
          9. Maximum Delta-T: 100°F
          10. Minimum Side Clearance: Shall not exceed 1” between any number of boilers.
          11. Maximum Allowable Operating Setpoint: 200°F
          12. 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.
      12. The boiler shall have its efficiency witnessed and certified by an independent third party, and the efficiency must be listed on the AHRI directory (www.ahridirectory.org) for natural gas operation. The test parameters for efficiency certification shall be the BTS-2000 standard. The certified thermal efficiency for natural gas firing shall not be less than **[EDR-750: 97.1%] [EDR-1000: 95.3%] [EDR-1500: 93.5%] [EDR-2000: 93.7%]**.
      13. A zero flow or low flow condition shall not cause any harm to the pressure vessel or heat exchanger of the boiler. 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 are unacceptable.
      14. The dimensions of the boiler shall not be more than (Height x Width x Depth) **[EDR-750/1000: 68” x 28” x 38”] [EDR-1500/2000: 80” x 34” x 61”]**.
      15. The dry weight of the boiler shall not be less than **[EDR-750/1000: 1,430 lbs] [EDR-1500: 2,260 lbs] [EDR-2000: 2,360 lbs]**.
      16. 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.
      2. Pressure and Temperature Gauge: Minimum 3-1/2” diameter, combination pressure and -temperature gauge. Gauges shall have operating-pressure and -temperature ranges so normal operating range is about 50 percent of full range.
         1. Mounted in the field in the boiler supply water piping prior to the first isolation valve by the boiler installer.
      3. Combustion Air Inlet Filter: 50 Micron.
      4. 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.
      5. Flue Gas Condensate Neutralization: pH neutralization accommodations available upon request.
   4. CONTROLS
      1. The boiler electrical controls 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, alarm horn speaker, boiler status, configuration, history and diagnostics.
         2. Integral controls power supply.
         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:
         1. System shall use algorithms to automatically adjust the fuel/air ratio during operation, optimizing combustion reliability, flame stability, combustion efficiency, and the dewpoint temperature for formation of flue gas condensate.
         2. O2 monitoring-only type systems that cannot automatically adjust combustion for seasonal variability shall not be accepted. Systems that trim but at less than a 100% duty cycle are unable to cope with rapid changes in operating conditions and shall not be accepted.
      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. Lag boiler stages are enabled according to heating demand. Boilers shall modulate in parallel as a cohesive unit according to heating demand.
          3. When all available boilers are active they may 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 communication interface with BAS shall enable BAS operator to remotely enable and monitor the boiler plant from an operator workstation.
          1. The boilers will communicate with each other and the Building Automation System via a daisy chain addressed Modbus network. Field wiring between nodes shall be twisted pair low voltage with shielded ground.
          2. **[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.
          3. **[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: 120 V.
        2. Phase: Single.
        3. Frequency: 60 Hz.
  2. VENTING
     1. The boiler shall be capable of operating with a stack effect not exceeding -0.04” W.C. and a combined air intake and exhaust venting pressure drop not exceeding +1.50” 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 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. **[Optional Method:]** Common Exhaust Vents: The draft system shall be designed for Category II and to prevent the backflow of exhaust gases through idle boilers.
     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.
      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.
            2. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
      3. Remove and replace malfunctioning units and retest as specified above.
      4. Occupancy Adjustments: When requested within 12 months of startup, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to 2 visits to Project during other than normal occupancy hours for this purpose.

END OF SECTION 235216