SECTION 235216 - STAINLESS STEEL FIRETUBE CONDENSING BOILERS

1. GENERAL
   1. SUMMARY
      1. This Section includes packaged, factory-fabricated and -assembled, gas-fired, firetube ferritic 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. AXA XL
      5. NFPA 70 National Electric Code (NEC)
      6. CSA 4.9, ANSI Z21.13
      7. AHRI-1500
      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. Product Data Submittal (“PDS”) End Assembly Drawing: Detail overall dimensions, connection sizes, connection locations, and clearance requirements.
         2. Wiring Diagrams: Detail electrical requirements for the boiler including 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 160°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 organization.
      9. Operation and Maintenance Data: To be included in the boiler Installation, Operation and Maintenance 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. CSA/ANSI Compliance: Boilers must be tested for compliance with ANSI Z21.13/CSA 4.9, “Gas-fired low pressure steam and hot water boilers.” Boilers shall be listed and labeled by ETL, and bear the ETL mark as a complete, factory-packaged boiler.
      7. AHRI Compliance: Boilers shall be witness tested and rated in accordance with the AHRI-1500 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 a period of fifteen (15) years, non-prorated, from the date of shipment from the factory.
         2. Warranty Period for the Burner: The boiler manufacturer shall warranty the 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 XE series boilers as manufactured by Fulton. 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 XE model **[EXE-399] [EXE-500] [EXE-650] [EXE-750]** 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, ferritic stainless steel firetube condensing boiler with heat exchanger sealed pressure tight, built on a steel base; including flue gas vent and 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. For closed-loop water heating service only.
      2. Pressure Vessel: Design and construction shall be in accordance with Section IV of the ASME Code for heating boilers.
         1. The pressure vessel shall be a counter-flow design with internal water-baffling.
         2. The boiler return and supply water connections shall be NPT. The water connections shall not be designed to support an external structural load from the piping system.
         3. The water volume of the boiler shall not be less than **[EXE-399/500: 10.4] [EXE-650/750: 17.9]** gallons.
         4. The maximum water pressure drop across the boiler inlet and outlet connections at a high-fire 20°F delta-T shall not exceed **[EXE-399: 1.2] [EXE-500: 2.0] [EXE-650: 1.4] [EXE-750: 1.9]** psig.
      3. Heat Exchanger: The heat exchanger is defined as the surfaces of the pressure vessel where the heat of combustion gases is transferred to the hydronic heating liquid.
         1. 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.
         2. Furnace to tube connections shall be constructed with low weld heat 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.
         3. 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.
         4. To ensure long heat exchanger life, the design shall be such that tubesheet to tube weld stresses while the boiler is in operation shall never exceed 3.5 ksi. Alternate boilers to the basis of design model and manufacturer shall provide a factory Finite Element Analysis (FEA) report detailing compliance, no exceptions will be granted.
         5. Material: The heat exchanger furnace, tubesheets, and firetubes shall be constructed of ferritic alloy stainless steel. Austenitic stainless steels such as 316Ti, 316L and 304 provide insufficient yield strength and are subject to catastrophic Chloride Stress Corrosion Cracking failure, and thus are not accepted.
            1. For long term durability, heat exchanger material of construction must have a minimum Ultimate Tensile Strength of 66 ksi, and a minimum 0.2% Yield Strength of 41 ksi. Weaker materials of construction with reduced strength are not accepted. Boilers seeking an approval must provide documentation that supports this requirement or will be rejected.
            2. Heat exchangers constructed of cast aluminum, mild steel, cast iron or copper finned tube materials are not accepted.
      4. Exhaust Manifold: Shall collect flue gases and flue gas condensate for safe disposal and shall be of stainless steel construction.
      5. Burner: Standard natural gas, forced draft.
         1. Air and gas pre-mix on the suction side of the fan with ratio controlled electronically by a Flame-by-Wire™ combustion control system.
         2. Turndown: Burner modulation ratio shall be no less than 8:1.
         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.
         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 centrifugal fan to operate during each burner firing sequence and to pre-purge and post-purge the combustion chamber.
         1. Motor: 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.
      7. 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. For burners with inputs exceeding 400,000 BTU/hr the gas train shall be complete with factory mounted and wired high and low gas pressure switches in compliance with CSD-1.
      8. Boiler Enclosure:
         1. Cabinet: Jacketed steel enclosure with full height front access door, fully removable 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.
         4. Combustion Air: Connection at the rear of the boiler.
      9. Rigging and Placement: The boiler shall include provisions for pallet jack and forklift handling.
      10. 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: 4 GPM
          6. Maximum Water Delta-T: 50°F default; configurable to 100°F where conditions allow
          7. Maximum Operating Setpoint Temperature: 185°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.
      11. 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.
      12. The dimensions of the boiler from where service clearances are measured shall not be more than (Height x Width x Depth) 73.7” x 26.3” x 28.9”.
      13. 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. Integrated Control Panel: Shall include the following factory mounted and wired devices:
         1. User Interface: 5-inch color touchscreen control display on the front exterior panel. The user interface shall allow access for configurating parameters, boiler control and monitoring; and shall feature a screen saver, boiler status, configuration, history and diagnostics.
         2. Flame Safeguard.
         3. Field Connections Terminals.
         4. Controls Transformers and Power Supplies: 24VAC, 24VDC, 5VDC
      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 electronic high temperature 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 fan pressure is proven.
         4. Blocked Intake Switch: Prevent operation unless sufficient combustion air is proven.
         5. Condensate Float Switch: Prevent operation in the event of a blocked condensate drain.
      3. Fuel/Air Ratio Controls: Maintain the ratio of fuel to air throughout the burner modulation range.
         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 motor position tolerances shall be no greater than +/- 0.1° 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.
         3. Combustion air flow shall be controlled by variable fan speed and a closed-loop motor actuated butterfly valve with position feedback.
         4. Gaseous fuel flow shall be controlled by a separate closed-loop motor actuated butterfly valve with position feedback.
         5. The air/fuel ratio shall be optimized across the entire modulation range through the use of a non-linear combustion curve. Ignition, low fire to high fire shall be comprised of ten (10) total points where each point includes discrete electronic parameters for fan speed, air position, and gas position. Two (2) point controls only allow for low fire and high fire settings, are incapable of generating a non-linear combustion curve, and thus will not be accepted.
         6. O2 Compensation™: 100% duty cycle system to maximize efficiency throughout seasonality:
            1. System shall use feed-forward algorithms to automatically adjust the fuel-air ratio during operation prior to entering the burner thus optimizing combustion reliability, flame stability, combustion efficiency, and the dewpoint temperature for formation of flue gas condensate.
            2. O2 feedback or 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. Temperature Operating Controls and Instrumentation:
         1. Outlet (supply) operating water temperature sensor: Sensor shall be dual-element type.
         2. Inlet (return) water temperature sensor.
         3. Combustion air temperature sensor.
         4. Flue gas exhaust temperature sensor: Probe shall be stainless steel.
         5. Proportional Integral Derivative (PID) temperature load control capability for hydronic and domestic hot water in standalone or lead-lag operation.
         6. Time of day display.
         7. Customizable boiler name display.
         8. Alarm history for a minimum 100 most recent alarms including status at time of lockout.
         9. Administrative password protection options.
         10. **[Optional:]** A field wired domestic hot water (DHW) temperature sensor is required for indirect DHW priority.
         11. **[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 air temperature, and disable the boilers above a configurable outdoor air 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.
      5. Pump and Motorized Valve Controls:
         1. 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.
            3. In variable primary arrangements utilizing integrated lead-lag, the control shall hold the lead boiler isolation valve open at all times.
         2. Dedicated boiler (primary) pump control:
            1. A dry contact start/stop signal shall be provided. The contact shall be configurable to close upon local burner demand and shall open after a time delay when burner demand ends.
            2. Variable speed signal shall be provided to modulate dedicated boiler (primary) pump speed with a 4-20mA output signal.
         3. System (secondary) pump control:
            1. A dry contact start/stop signal shall be provided. The contact shall be configurable to close when the plant exits warm weather shutdown mode, and open when the plant enters warm weather shutdown mode.
         4. Domestic hot water (DHW) pump control:
            1. A dry contact shall be provided for a start/stop signal. The contact shall be configurable to close when a DHW heating demand exists and shall open when the DHW heating demand ends.
      6. 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 to be 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 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 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.
      7. 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: General Alarm.
            2. Control with Factory Installed Jumper: Interlock for External Device, Remote Enable (“BMS Start/Stop”), Emergency Stop (“E-Stop”).
            3. Remote Temperature Setpoint Signal: 4-20 mA
         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.
   5. 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: One.
         3. Frequency: 60 Hz.
   6. 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 1.25” 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 PVC/CPVC. Copper or carbon steel piping is not accepted.
   7. 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.
3. 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