

SECTION 235216 CONDENSING HOT WATER BOILERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, apply to this Section.

1.2 SUMMARY

- A. This Section includes packaged, factory-fabricated and -assembled, natural gas-fired, fire-tube condensing boilers, trim, and accessories for generating hot water.

1.3 SUBMITTALS

- A. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.
 - 1. Venting System: Venting layout and engineered calculations and drawings must be submitted to the Design Engineer prior to beginning installation to thoroughly demonstrate that size and configuration conform to recommended size, length, and footprint for each submitted boiler in accordance with the manufacturer's limitations and guidelines.
 - 2. Efficiency Curves: At a minimum, submit efficiency curves for 100%, 80%, 60%, 40% 20%, and 7% input firing rates at incoming water temperatures ranging from 80°F to 160°F. Test protocols shall conform to industry standards and shall be witnessed and reviewed by an industry accepted, independent, third party group.
 - 3. Pressure Drop Curve: Submit pressure drop curve for flows ranging from 0 GPM to maximum value of the boiler.
- B. Shop Drawings: For boilers, boiler trim, and accessories. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Wiring Diagrams: Power, signal, and control wiring.
- C. Source quality-control test reports.
- D. Field quality-control test reports.
- E. Warranty: Special warranty specified in this Section.
- F. Other Informational Submittals as it pertains to the respective boiler input rating:
 - 1. ASME Stamp Certification and Report: Submit "A," "S," or "PP" stamp certificate of authorization, as required by authorities having jurisdiction, and document hydrostatic testing of piping external to boiler.

1.4 QUALITY ASSURANCE

- A. 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.
- B. I=B=R Performance Compliance: Condensing boilers must be rated in accordance with applicable federal testing methods and verified by AHRI as capable of achieving the energy efficiency and performance ratings as tested within prescribed tolerances.
- C. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.
- D. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."
- E. DOE Compliance: Minimum efficiency shall comply with 10 CFR 430, Subpart B, Appendix N, "Uniform Test Method for Measuring the Energy Consumption of Furnaces and Boilers."
- F. UL Compliance: Test boilers for compliance with UL 795, "Commercial-Industrial Gas Heating Equipment." Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.
- G. NOx Emission Standards: When installed and operated in accordance with manufacturer's instructions, condensing boilers shall comply with the NOx emission standards as required by the State of New Jersey. Boiler manufacturer shall provide documentation indicating compliance.

1.5 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.6 WARRANTY

- A. Special 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 commencing at the date of substantial completion. Final warranty offerings shall be in accordance with Section 01850.
 - 1. Warranty Period for Fire-Tube Condensing Boilers:
 - a. Standard Warranty, All Components (minus igniter, flame detector and O2 sensor): 2-year warranty from shipment.
 - b. Pressure Vessel/Heat Exchanger Damaged by Thermal Stress, Corrosion, Mechanical Defects or Workmanship: Non-prorated, for 15 years from date of Shipment. Warranty to include parts only.
 - c. Control Panel assembly shall carry a 2 year warranty from shipment against failure due to defective materials of workmanship. Warranty to include parts only.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. For Boilers with input ratings of less than 3,000 MBH:
1. Manufacturers: Subject to compliance with requirements, provide proprietary products by the following:
 - a. AERCO International; Benchmark Platinum Series.
 - b. Lochinvar; Crest Series.
 - c. Fulton; Endura+ Series.
 - d. Or approved equivalent.

2.2 MANUFACTURED UNITS

- A. Description: Boiler shall be natural gas fired, fully condensing, fire-tube design. Power burner shall have full modulation and discharge into a positive pressure vent. Boiler efficiency shall increase with decreasing load (output), while maintaining setpoint. Boiler shall be factory-fabricated, factory-assembled, and factory-tested, fire-tube condensing boiler with heat exchanger sealed pressure-tight, built on a steel base, including insulated jacket, flue-gas vent, combustion-air intake connections, water supply, return and condensate drain connections, and controls. The boiler shall be capable of handling return water temperatures down to 40 deg F without any failure due to thermal shock or fireside condensation.
- B. Casing:
1. Jacket: Sheet metal, with snap-in or interlocking closures.
 2. Control Compartment Enclosures: NEMA 250, Type 1A.
 3. Finish: Baked-enamel protective finish.
 4. Insulation: Minimum 2-inch-thick, mineral-fiber or polyurethane-foam insulation surrounding the heat exchanger.
 5. Combustion-Air Connections: Inlet and vent duct collars.
 6. Mounting base to secure boiler.
 - a. Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler pressure vessel, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" when mounting base is anchored to building structure.
- C. Heat Exchanger:
1. The heat exchanger shall be constructed of 439 stainless steel fire tubes and tubesheets, with a one-pass combustion gas flow design. The fire tubes shall be 5/8" OD, with no less than 0.049" wall thickness. The upper and lower stainless steel tubesheet shall be no less than 0.25" thick. The pressure vessel/heat exchanger shall be welded construction. The heat exchanger shall be ASME stamped for a working pressure not less than 150 psig. Access to the tubesheets and heat exchanger shall be available by burner and exhaust manifold removal. Minimum access opening shall be no less than 8-inch diameter.

D. Pressure Vessel:

1. For Boilers with input ratings of 2,500 MBH: The pressure vessel shall have a maximum water volume of 58 gallons. The boiler water pressure drop shall not exceed 3 psig at 218 gpm. The boiler water connections shall be 4 inch flanged 150 pound, ANSI rated. The pressure vessel shall be constructed of SA53 carbon steel, with a 0.25 inch thick wall and 0.50-inch thick upper head. Inspection openings in the pressure vessel shall be in accordance with ASME Section IV pressure vessel code. The boiler shall be designed so that the thermal efficiency increases as the boiler firing rate decreases.

E. Dual Returns:

1. The boiler shall include dual return connections for low and high return temperature zones for added flexibility and thermal efficiency optimization. The boiler shall not have a minimum flow rate requirement through either return connection as long as the specified minimum flow of the boiler is met through a combination of the two return connections. Boilers with dual returns are preferred.

F. Modulating Air/Fuel Valve and Burner:

1. For Boilers with input ratings of 2,500 MBH: The boiler burner shall be capable of a 15 to 1 turndown ratio of the firing rate without loss of combustion efficiency or staging of gas valves. The burner shall not operate above 7.5% oxygen level or 55% excess air. The burner shall produce less than 13 ppm of NOx, under standard calibration, corrected to 3% excess oxygen when firing on natural gas. The burner shall be metal fiber mesh covering a stainless steel body with spark or proven pilot ignition and flame rectification. All burner material exposed to the combustion zone shall be of stainless steel construction. There shall be no moving parts within the burner itself. A modulating air/fuel valve shall meter the air and fuel input. The modulating motor must be linked to both the gas valve body and air valve body with a single linkage. The linkage shall not require any field adjustment. A variable speed cast aluminum pre-mix blower shall be used to ensure the optimum mixing of air and fuel between the air/fuel valve and the burner.

G. Minimum boiler efficiencies shall be as follows at a 20 deg F temperature difference:

EWT	100% Fire	50% Fire	7% Fire
160 °F	86.5%	87%	87%
120 °F	88.5%	89%	90%
80 °F	95.6%	96.8%	98.2%

H. Blower: Variable speed, DC centrifugal fan to operate during each burner firing sequence and to pre-purge and post-purge the combustion chamber.

1. Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
 - a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

I. Gas Train:

1. For Boilers with input ratings of 3,000 MBH or less: Combination gas valve with manual shutoff and pressure regulator. Gas train shall be IRI "double-block and bleed" type capable of operating with minimum gas pressure of 4" W.C. at full load rated capacity.
- J. Ignition: Spark ignition with 100 percent main-valve shutoff with electronic flame supervision.
- K. Exhaust Manifold: The exhaust manifold shall be of corrosion resistant cast aluminum or 316 stainless steel. The exhaust manifold shall have a collecting reservoir and a gravity drain for the elimination of condensation.
- L. Combustion Air: The boiler shall be designed such that the combustion air is drawn from the inside of the boiler enclosure, decoupling it from the combustion air supply and preheating the air to increase efficiency.
- M. Combustion Air Filter: The boiler shall be equipped with an automotive high flow air filter to ensure efficient combustion and unhindered burner components operation.
- N. O2 Sensor in Combustion Chamber: The boiler shall be equipped with an Oxygen sensor. The sensor shall be located in the boiler combustion chamber. Boilers without Oxygen sensor or boilers with an Oxygen sensor in the exhaust shall not be acceptable due to measurement estimation and performance accuracy.
- O. Muffler: Stainless steel intake and exhaust mufflers provided by boiler manufacturer. Refer to contract documents for rooms requiring the mufflers.
- P. Condensate Neutralizing Kit: The condensate neutralizing kit shall be provided by the boiler manufacturer in type and quantity as required for the boiler input MBH. The kit shall be capable of being mounted in horizontal or vertical configuration.

2.3 TRIM

- A. Include devices sized to comply with ANSI B31.1, "Power Piping, ANSI B31.9, "Building Services Piping."
- B. Aquastat Controllers: Operating, firing rate, and high limit.
- C. Safety Relief Valve: ASME rated in PSIG as noted on contract documents.
- D. Pressure and Temperature Gage: Minimum 3-1/2-inch-diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges so normal operating range is about 50 percent of full range.
- E. Boiler Air Vent: Automatic.
- F. Drain Valve: Minimum NPS 3/4 hose-end gate valve.

2.4 CONTROLS

- A. Refer to Division 23 Section "HVAC Instrumentation and Controls."

- B. Boiler operating controls, as provided by the Boiler Manufacturer shall be UL listed.
- C. The boiler shall have an integrated boiler control that is capable of operating the boiler and associated accessories including but not limited to: its pumps, valves, and dampers.
 - 1. The control shall have a 5 inch color touch screen display as well as six function buttons that are separate from the display. User shall have the ability to navigate the menus via touchscreen or navigation buttons. Controls not equipped with navigation button options shall not be permitted.
 - 2. The control shall be equipped with a multi-color linear LED light to indicate the level of firing and/or air/fuel valve position.
 - 3. The control shall display two temperatures using two dedicated three-digit seven-segment displays.
 - 4. The control shall offer an Enable/Disable toggle switch as well as two buttons for Testing and Resetting the Low Water Cutoff.
- D. The Manager designated boiler control shall be capable of the following functions without the need for additional external controls:
 - 1. Sequence up to 16 boilers,
 - 2. Control boiler variable speed or single speed pumps and/or modulating motorized valves,
 - 3. Operate or modulate a variable or single speed system pump or rotate two system pumps,
 - 4. Control and communicate with up to 6 SmartPlate domestic water heaters and their domestic hot water pump,
 - 5. The control shall connect to other plant boiler controls using RS485 and communicate using Modbus protocol.
- E. The control system shall be segregated into three components: “Edge [ii]” Control Panel, Power Panel, and Input/Output Connection Box. The entire system shall be Underwriters Laboratories recognized.
- F. The control panel shall consist of seven individual circuit boards using surface-mount technology in a single enclosure. Each board shall be individually field replaceable. These circuit boards shall include:
 - 1. A microcontroller board with integrated 5 inch touchscreen color display providing the user interface.
 - 2. A 7-segment display board. This board includes two 3-digit 7-segment displays. These displays shall be used to view a variety of temperature sensor values and operating and startup function status.
 - 3. An Interface board connects the microcontroller board to internal components using ribbon cables.
 - 4. An electric low-water cutoff board connects to the test and manual reset functions on the microcontroller board.
 - 5. A power supply board is designed to provide the different DC voltages to the rest of the boards. It also acts as voltage regulator and reduce power noise.
 - 6. An ignition and combustion board. This board controls the air/fuel valve and Safety Shutoff Valve, flame status and ignition transformer
 - 7. A connector board used to connect all external electrical connection.
- G. Combination plant: The managing boiler control shall be capable of setting and managing a combination plant that consist of up to two groups of boilers, their swing boilers and swing

valves. The control shall be capable of performing all the listed features without the need for any additional controls. The use of additional controls to achieve any of these functionalities shall be prohibited to simplify installation and plant management. The combination plant control shall have the following capabilities:

1. The control shall operate one group of boilers for heating and another group of boilers for domestic hot water using plate heat exchangers or indirect tanks.
 2. The control shall manage and rotate the lead boiler in each of the two groups independent of the other group.
 3. The control shall be capable of managing one or two swing boilers and their motorized swing valves to direct the output of the swing boiler(s) to one of the two groups based on the plant priority settings. The control shall also connect to the header and return sensors for each of the two groups of boilers and use those values to manage the set point for each group.
 4. The control shall offer two independent logics that run simultaneously managing each group of boilers. Each boiler group logic shall have its temperature values, setpoints, PID and feedback parameters that is independent of the other group settings and parameters.
- H. System Pump lead/lag rotation: The control shall be capable of operating two system pumps. It shall rotate the lead pump based on user time setting. The use of an external pump lead-lag control shall not be permitted unless function is performed by building management system.
- I. Variable Speed Pump: The control shall be capable of modulating a variable speed pump. It shall modulate the pump based on the boiler firing rate, the boiler plant firing rate, or based on the return header temperature differential from supply water temperature on a primary secondary piping application.
- J. Minimum number of boiler plant open valves: The control shall manage the minimum number of boiler motorized valves to reduce variable speed pump flow and energy used. The control shall offer a setting to control the number of valves open during low load and standby operation. Manufacturers without this feature shall offer additional pump controller and a smaller single speed pump to run during the low load and standby periods.
- K. Control settings transfer using USB: The control shall simplify and significantly lessen startup and boiler setting time by being able to use a USB flash drive to copy settings from one boiler to another boiler. Installers shall use successfully preconfigured boiler settings in their portfolio to newly installed boilers.
- L. Combustion calibration: The control shall offer at least 5 calibration points. The use of less than 5 calibration points is not permitted to improve overall system efficiency under all firing rates. Each combustion calibration point shall operate with 5 to 7% O₂ levels to improve operating efficiency. Deviating away from these values shall not be acceptable.
- M. Assisted Combustion Calibration: The control shall offer an assisted combustion calibration feature to help reduce setup time and improve setup accuracy. The assisted combustion calibration shall adjust the O₂ level at each calibration point to help keep O₂ level within allowable efficiency. The control shall log, date and time stamp the calibrated point combustion values of O₂ and allow the user to log NO_x, CO, and flame strength. The control shall check these values against manufacturer allowable combustion values and color identify values out of manufacturer acceptable ranges. As an additional capability, the control shall also have the ability to perform manual combustion calibration. Not having Assisted Combustion Calibration function shall be prohibited.

- N. Valve Balancing: To help simplify installation and as part of a boiler plant, the control shall be capable of controlling an electronic modulating motorized valve for each of the boilers using the manager boiler control. It shall have a built-in logic to provide a maximum flow using an adjustable valve opening percentage point for each boiler. The control shall be capable of closing any valve that has an off boiler. If all boilers are off, the control shall keep at minimum one valve open to protect pumps.
- O. Building Automation: The control shall be able to communicate to Building Management Systems using BACnet and Modbus without the use of external gateways. The control shall be able to communicate over each of the two protocols using IP as well as RS485. The use of external gateways is not acceptable. The control shall be able to communicate to the building management system using:
 - 1. BACnet MS/TP and BACnet IP/Ethernet. When communicating over BACnet IP, the control shall offer an additional layer of IP security by mapping all control BACnet IP communication to the BACnet server's IP and MAC addresses. Not having this level of security shall deem the IP communication insecure and shall not be acceptable.
 - 2. Modbus RTU and Modbus IP.
- P. Unit and Plant Status: The control shall provide a quick view of the unit status and plant status.
 - 1. The unit status screen shall provide temperature setpoint, all water inlet and outlet and supply air and exhaust temperature sensors' values. It shall also provide unit current and target firing rates. Additional screens shall display unit run hours, cycle count and average cycles per hour.
 - 2. The plant status screens shall provide plant temperature setpoint, plant water supply and return temperatures, outdoor temperature, and domestic hot water setpoint and current temperatures. Additionally, a status screen shall show the boiler status of each plant unit, plant firing rate.
 - 3. Unit and Plant event history: The manager control shall display the last 500 historical events per plant or 200 historical events for single unit installations.
- Q. Software update: The control shall be capable of field software updates without a need for hardware component(s) replacement. This shall be performed either using software on a USB flash drive or via Internet connection. The software update mechanism shall be performed by a trained technician. The software update menus shall be secured using a password level. After the software update, the control shall retain all of its prior field settings.
- R. Copy settings from one boiler to the other: To significantly reduce installation time by reducing long repetitive work, the control shall have the capability of saving its settings to a USB flash drive. In addition, the control shall have the ability of copying new settings from a flash drive.
- S. Programmable Inputs and Outputs: The control shall be equipped with multiple relay and analog outputs and dry contact and analog inputs. Each shall be field programmable to meet installation needs. The following I/O options shall be available:
 - 1. Relay outputs: There shall be two output relays that are programmable. The following relay functions shall be selectable:
 - a. Swing Valve 2
 - b. System Pump
 - c. Summer Pump
 - d. Multi-temperature pump

- e. Pump2
 - f. Louver
- 2. Inputs and interlocks: The following control functions shall be available:
 - a. Flow input
 - b. Damper end switch input
 - c. Louver end switch input
 - 3. Analog output: There shall be three analog outputs that are programmable. The control shall have configurable analog outputs that can be used as one of the following options:
 - a. Boiler pump
 - b. Domestic hot water variable speed pump
 - c. Valve
 - d. Fire rate
 - 4. Analog input: There shall be three analog inputs that are programmable. The control shall have configurable analog inputs that can be used as one of the following options:
 - a. Remote setpoint
 - b. Smart Plate valve position
 - c. Domestic hot water variable speed pump flow
- T. Backup boiler: The control shall be able to operate a lower efficiency back up boiler during peak periods when main plant boilers are at or close to peak load.
- U. Communication with SmartPlate: The control shall be capable of controlling and monitoring one or multiple plate heat exchanger(s). It shall be able to:
- 1. Change the domestic hot water temperature setpoint and read its current temperatures.
 - 2. Monitor 3-way valve position.
 - 3. Control the operation of the domestic hot water pump.
- V. The controls shall annunciate boiler and sensor status and include extensive self-diagnostic capabilities.
- W. The control panel shall incorporate:
- 1. Setpoint High Limit: Setpoint high limit allows for a selectable maximum boiler outlet temperature and acts as temperature limiting governor. Setpoint limit is based on a PID function that automatically limits firing rate to maintain outlet temperature within a 0 to 10 degree selectable band from the desired maximum boiler outlet temperature.
 - 2. Setpoint Low Limit: Allow for a selectable minimum operating temperature.
 - 3. Failsafe Mode: Failsafe mode allows the boiler to switch its mode to operate from an internal setpoint if its external control signal is lost, rather than shut off. This is a selectable mode, enabling the control to shut off the unit upon loss of external signal, if so desired.
- X. The boiler control system shall incorporate the following additional features for enhanced external system interface:
- 1. System start temperature feature
 - 2. Pump delay timer
 - 3. Auxiliary start delay timer
 - 4. Auxiliary temperature sensor

5. Analog output feature to enable simple monitoring of temperature setpoint, outlet temperature or fire rate
 6. Remote interlock circuit
 7. Delayed interlock circuit
 8. Easy Setup by providing simplified menu quick settings to expedite plant and boiler setup
 9. Delta-T Limiter
 10. Freeze protection
 11. Fault relay for remote fault alarm
 12. Warm-weather shutdown
 13. The control shall offer multi-level user security access using different passwords. For additional security, the passwords shall expire if control display was not touched for an extended period 30 minutes.
- Y. Each boiler shall include an electric, single-seated combination safety shutoff valve/regulator with proof of closure switch in its gas train. Each boiler shall incorporate dual over-temperature protection with manual reset, in accordance with ASME Section IV and CSD-1.
- Z. O₂-Trim or AERtrim: Each boiler shall be equipped with the patented AERtrim system, an advanced O₂-trim system for condensing boiler applications. The system shall utilize a low cost reliable automotive O₂ sensor that measures and monitors the oxygen content of the exhaust gases. The system shall adjust the blower speed to maintain optimal air-fuel ratios in the event of any site condition changes (air density, gas pressure, BTU content, etc.). The system shall have the following capabilities:
1. Self-Diagnostics
 - a. System Status and Error Messages
 - b. When excessive trimming is occurring
 - c. When O₂ sensor has fallen out of calibration
 2. Adjustable parameter settings
 - a. O₂ target and range to meet site requirements
 - b. Schedule daily or weekly self-diagnostics

Output of O₂ information shall be displayed on the Edge [ii] control panel.

The O₂ sensor shall be installed through the unit's burner plate and measure the oxygen content directly within the unit's combustion chamber.

Boilers without an equivalent O₂ trim will be deemed unacceptable. Due to the moisture content of flue gases from condensing boilers, placing the O₂ sensor in the exhaust manifold or stack will be deemed unacceptable.

Boilers which require their O₂ sensor be changed annually will be deemed unacceptable.

- AA. Each boiler shall be onAER ready with a standard Ethernet port and include a 5 year onAER subscription at no additional charge. AERCO's onAER service grants the user online access to real time operation and status of their system plant from any computer, tablet, or mobile device along with the following capabilities:
1. Efficiency status and trends
 2. O₂ levels
 3. Efficiency and performance optimization tips

4. Preventative Maintenance alerts and scheduling
5. Predictive Maintenance algorithms.
6. Warning and error messages
7. Weekly or monthly performance and status reports
8. Manage multiple boiler plants or buildings
9. Customizable dashboard
10. Add email contacts for alerts and reports, including local AERCO trained technicians
11. Manage and store startup, maintenance, and service documentation

The boiler manufacturer shall be able to provide a network hub or a network switch to connect up 16 boilers to an online network.

BB. Each boiler shall have integrated Boiler Sequencing Technology (BST), capable of multi-unit sequencing with lead-lag functionality and parallel operation. The system will incorporate the following capabilities:

1. Efficiently sequence 2-to-16 units on the same system to meet load requirement.
2. Integrated control and wiring for seamless installation of optional modulating motorized valve. When valves are utilized, the system shall operate one motorized valve per unit as an element of load sequencing. Valves shall close with decreased load as units turn off, with all valves open under no-load conditions.
3. Automatically rotate lead/lag amongst the units on the chain and monitor run hours per unit and balance load in an effort to equalize run hours among active units.
4. Option to manually designate lead and last boiler
5. Designated manager control, used to display and adjust key system parameters.
6. Automatic bump-less transfer of master function to next unit on the chain in case of designated master unit failure; master/slave status shall be shown on the individual unit displays.

CC. For boiler plants greater than 16 units, the Boiler Manufacturer shall supply as part of the boiler package a completely integrated AERCO Control System (ACS) to control all operation and energy input of the multiple boiler heating plant. The ACS shall be comprised of a microprocessor based control utilizing the MODBUS protocol to communicate with the Boilers via the RS-485 port. One ACS controller shall have the ability to operate up to 32 AERCO boilers.

The controller shall have the ability to vary the firing rate and energy input of each individual boiler throughout its full modulating range to maximize the condensing capability and thermal efficiency output of the entire heating plant. The ACS shall control the boiler outlet header temperature within $\pm 2^{\circ}\text{F}$. The controller shall be a PID type controller and uses Ramp Up/Ramp Down control algorithm for accurate temperature control with excellent variable load response. The ACS controller shall provide contact closure for auxiliary equipment such as system pumps and combustion air inlet dampers based upon outdoor air temperature.

The ACS shall have the following anti-cycling features:

- Manual designation of lead boiler and last boiler.
- Lead boiler rotation at user-specified time interval.
- Delay the firing/shutting down of boilers when header temperature within a predefined dead band.

When set on Internal Setpoint Mode, temperature control setpoint on the ACS shall be fully field adjustable from 50°F to 190°F in operation. When set on Indoor/Outdoor Reset Mode, the ACS will operate on an adjustable inverse ratio in response to outdoor temperature to control the main header temperature. Reset ratio shall be fully field adjustable from 0.3 to 3.0 in operation. When set on 4ma to 20ma Temperature Control Mode, the ACS will operate the plant to vary header temperature setpoint linearly as an externally applied 4-20 ma signal is supplied.

When set on MODBUS Temperature Control Mode, the ACS will operate the plant to vary header temperature setpoint as an external communication utilizing the MODBUS protocol is supplied via the RS-232 port. The ACS controller shall have a vacuum fluorescent display for monitoring of all sensors and interlocks. Non-volatile memory backup of all control parameters shall be internally provided as standard. The controller will automatically balance the sequence of operating time on each boiler by a first-on first-off mode and provide for setback and remote alarm contacts. Connection between central ACS system and individual boilers shall be twisted pair low voltage wiring, with the boilers 'daisy-chained' for ease of installation.

DD. Unit-mounted Communication Interface

1. Description: Multi-protocol, communications gateway to support integration with building management system. Communication interface shall support integration with Johnson N2, BACnet and LonWorks systems. Gateway shall include all adapters required to interface with building management system.
2. Enclosure: UL-recognized plastic enclosure for mounting on unit or remotely on an adjacent wall.
3. Ports: RS232 and RS485 communication ports.
4. Signal Limits: Capable of accepting signals from up to twelve boilers.
5. Memory: Battery-backed memory; lithium 3-volt coin cell.

EE. Controls Accessories

1. Outdoor Air Sensor Kit.
2. Supply Header Sensor Kit.
 - a. Include two sensor replacements.
3. RS-232 to RS-485 Converter (based on field conditions).
4. Control transformers (as required).

2.5 ELECTRICAL POWER

- A. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 26 Sections.
- B. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.
 1. House in NEMA 250, Type 1 enclosure.
 2. Wiring shall be numbered and color-coded to match wiring diagram.
 3. Install factory wiring outside of an enclosure in a metal raceway.
 4. Field power interface shall be to motor is fused disconnect switch.

5. Provide each motor with over-current protection.

2.6 VENTING KITS

- A. Refer to Division 23 specification “Breechings, Chimneys and Stacks.”
- B. Venting products, termination locations and installations shall follow manufacturer guidelines and specifications in strict accordance.
- C. Exhaust Vent: Complete system, ASTM A 959, Type 29-4C stainless steel, pipe, vent terminal, thimble, indoor plate, vent adapter, condensate trap and dilution tank, and sealant. The exhaust vent must be UL Listed for use with Category III and IV appliances and compatible with operating temperatures up to 480°F, positive pressure, condensing flue gas service. UL listed vents of AL 29-4C stainless steel must be used with boilers.
- D. Combustion-Air Intake: Boilers shall be capable of drawing combustion air from the outdoors via a metal or PVC duct connected between the boiler and the outdoors.
- E. For boilers larger than 750 MBH input, common vent and common combustion air must be an available option for boiler installation. Consult manufacturer for common vent and combustion air sizing.
- F. Follow guidelines specified in manufacturer’s venting guide.

2.7 SOURCE QUALITY CONTROL

- A. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.
- B. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.
 1. If boilers are not factory assembled and fire-tested, the local vendor is responsible for all field assembly and testing.
- C. Allow Owner access to source quality-control testing of boilers. Notify Design Engineer fourteen days in advance of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Before boiler installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and 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.
- B. Examine mechanical spaces for suitable conditions where boilers will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 BOILER INSTALLATION

- A. Boiler installation shall be completed in strict accordance with manufacturer's specific guidelines and instructions.
- B. Install boilers level on concrete base. Concrete base is specified in Division 23 Section "Common Work Results for HVAC," and concrete materials and installation requirements are specified in Division 03.
- C. Install gas-fired boilers according to NFPA 54.
- D. Assemble and install boiler trim.
- E. Install electrical devices furnished with boiler but not specified to be factory mounted.
- F. Install control wiring to field-mounted electrical devices.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to boiler to allow service and maintenance.
- C. 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.
- D. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas train connection. Provide a reducer if required.
- E. Connect hot-water piping to supply- and return-boiler tapings with shutoff valve and union or flange at each connection.
- F. Install piping from safety relief valves to nearest floor drain.
- G. Install piping from safety valves to drip-pan elbow and to nearest floor drain.
- H. Boiler Venting:
 1. Install flue venting kit and combustion-air intake.
 2. Connect full size to boiler connections. Comply with requirements in Division 23 Section "Breechings, Chimneys, and Stacks."

- I. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- J. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. 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.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level and water temperature.
 - b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- C. Remove and replace malfunctioning units and retest as specified above.
- D. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.
- E. Performance Tests:
 - 1. Full-load Thermal Efficiency:
 - a. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
 - b. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment to comply.
 - c. Perform field performance tests to determine capacity and efficiency of boilers.
 - 1) Test for full capacity.
 - 2) Test for boiler efficiency at full capacity.
 - d. Repeat tests until results comply with requirements indicated.
 - e. Provide analysis equipment required to determine performance.
 - f. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are not adequate.

- g. Notify Design Engineer in advance of test dates.
 - h. Document test results in a report and submit to Design Engineer.
- 2. Part-load Thermal Efficiency: The boiler manufacturer is expected to provide partial load thermal efficiency curves for review by the Design Engineer. These thermal efficiency curves must include at least three separate curves at various BTU input levels. If the boiler manufacturer does not have the curves and/or the curves are not deemed acceptable to the Design Engineer, the boiler manufacturer will be responsible to perform the following performance testing for efficiency at the different firing rates:
 - a. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
 - b. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment to comply.
 - c. Perform field performance tests to determine capacity and efficiency of boilers.
 - 1) Test for full capacity.
 - 2) Test for boiler efficiency at low fire 20, 40, 60, 80, 100, 80, 60, 40, and 20 percent of full capacity. Determine efficiency at each test point.
 - d. Repeat tests until results comply with requirements indicated.
 - e. Provide analysis equipment required to determine performance.
 - f. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are not adequate.
 - g. Notify Design Engineer in advance of test dates.
 - h. Document test results in a report and submit to Design Engineer.

3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain boilers in accordance with Section 01820.

END OF SECTION 235216