

## SECTION 235222 - CONDENSING BOILERS

## PART 1 - GENERAL

## 1.1 SECTION INCLUDES

- A. Condensing, Modulating Boilers

## 1.2 SUBMITTALS

- A. Submit shop drawings and product data per applicable Division I Specification.
- B. Product data and/or drawings shall be submitted to the engineer for approval and shall consist of:
  - 1. General assembly drawing of the boiler including product description, model number, dimensions, clearances, weights, service sizes, efficiency curves, etc.
  - 2. Schematic flow diagram of gas valve trains.
  - 3. Schematic wiring diagram of boiler control system that shows all components, interlocks, etc and shall clearly identify factory wiring and field wiring.
  - 4. Pressure Drop Curve. Submit pressure drop curve the following flow ranges per designated capacities below.
    - a. 2500 MBH: 0-400 GPM
    - c. If submitted material is different from that of the design basis, boiler manufacture shall incur all costs associated with reselection of necessary pumps. Possible differences include, but are not limited to, the pump type, pump pad size, electrical characteristics and piping changes.
- C. Full Function Factory Fire Test must be performed and documented on fire test label on boiler.
- D. Operation and Maintenance Manuals shall be submitted prior to final acceptance by the engineer and shall contain shop drawings, product data, operating instructions, leaning procedures, replacement parts list, maintenance and repair data, etc.

## 1.3 QUALITY ASSURANCE

- A. Unit shall be constructed in accordance with ASME Boiler and Pressure Vessel Code Section VIII.
- B. IBR compliance.
- C. The equipment shall, as a minimum, be in strict compliance with the requirements of this specification, shall perform as specified and shall be the manufacturer's standard commercial product unless specified otherwise.

- D. Electrically operated components specified are to be “Listed” and/or “Labeled” as defined by NFPA 70, Article 100.
- E. Boilers shall bear an ASME “H” stamp.
- F. Boiler shall be CSA certified.
- G. Boiler shall be AHRI listed and certified.

#### 1.4 WARRANTY

- A. The boiler manufacturer shall warrant each boiler, including boiler, trim, boiler control system, and all related components, accessories, and appurtenances against defects in workmanship and material for a period of twelve (12) months from date of startup (Not to exceed 18 months from date of shipment). Heat exchanger and fuel burner shall be warranted for a period of ten (10) years from date of shipment.

#### 1.5 COORDINATION

- A. Equipment shall be handled, stored and installed in accordance with the manufacturer’s instructions.

#### 1.6 CERTIFICATION

- A. Manufacturer’s Certification. The boiler manufacturer shall certify the following:
  - 1. The products and systems furnished are in strict compliance with the specifications.
  - 2. The boiler, burner and other associated mechanical and electrical equipment have all been properly coordinated and integrated to provide a complete and operable boiler.
  - 3. Each Boiler shall be ASME compliant.
  - 4. Each boiler shall be CSA certified for at least 92% efficiency based on operating conditions specified for testing under ANSI Z21.13/CSA 4.9.
  - 5. Each boiler shall be CSD-1 compliant.

### PART 2 - PRODUCTS

#### 2.1 MANUFACTURERS

- A. Aerco – Benchmark (Basis of Design)
- B. Cleaver Brooks - Clearfire
- C. Camus – Advantus
- D. Patterson Kelley – Storm

## 2.2 GENERAL

- A. The boiler plant consists of two (2) boilers with an input of 2,500 MBH with a gross output of 2,175 MBH. Each boiler shall be UL Listed, CSD-1 approved, ASME coded and stamped, and incorporate a gas train designed in accordance with FM or IRI. The boiler manufacturer must publish known part load value efficiencies; the thermal efficiency must increase as the firing rate decreases. Electrical service to each unit shall be 208V/3/60Hz, 20 amp service. The boiler control panel shall be proprietary in design and incorporate the functions of temperature control, combustion safeguard control, message annunciation, and fault diagnostic display, on individual field replaceable circuit boards mounted within a single housing. The boiler shall have an ASME approved relief valve setting of 50 psig.
- B. Construction:
  - 1. Boiler modules shall be natural gas fired, condensing fire tube design with a modulating forced draft power burner and positive pressure vent discharge.
- C. Main Gas Train
  - 1. Each boiler shall be provided with an integral main gas valve train. The main gas valve train(s) shall be factory assembled, piped, and wired. Each gas valve train shall include at least the following:
    - a. One (1) manual shutoff valve.
    - b. Two (2) safety solenoid valves. Valves equipped with dual solenoids that can be independently energized for leak testing and must be integrated into a single body design.
    - c. Air-Gas ratio control (maximum inlet pressure 14" W.C.).
    - d. One (1) low gas pressure switch (manual reset).
    - e. One (1) high gas pressure switch (manual reset) as required by code.
    - f. Two (2) pressure test ports.
  - 2. If gas pressure exceeds 14" W.C. the Contractor shall supply a suitable intermediate lockup type gas pressure regulator to reduce the pressure to acceptable levels. Mechanical contractor to extend regulator vent to the outdoors.
  - 3. The boiler manufacturer shall furnish each boiler with an integral power type fuel burner. The fuel burner shall be an assembly of a gas burner, combustion air blower, valve train, and ignition system. The burner manufacturer shall fully coordinate the burner as to the interaction of its elements with the boiler heat exchanger and the boiler control system in

order to provide the required capacities, efficiencies, and performance as specified.

4. Each burner shall be located near the top of combustion chamber with combustion gases flowing downward through the heat exchanger and constructed of stainless steel flange with perforated stainless steel inner backing plate and stainless steel outer knit.
5. Each boiler shall be equipped with direct spark ignition. Main flame shall be monitored and controlled by a flame rod (rectification) system.
6. Burner shall be capable of a 15:1 turndown.

D. Boiler safety and Trim Device

1. Boiler safety and trim devices shall be as follows:
  - a. Safety relief valve shall be provided in compliance with the ASME code.
  - b. Water pressure/temperature gauge.
  - c. Low Water/Flow cutoff.
  - d. Manual reset high limit water temperature controller.
  - e. Operating temperature control to control the sequential operation of the burner.
  - f. High and Low Gas Pressure switches as required.
  - g. Flame rod (rectification) system.

E. Heat Exchanger

1. Each hot water boiler shall consist of a stainless steel heat exchanger complete with trim, valve trains, burner, and boiler control system. The boiler manufacturer shall fully coordinate the boiler as to the interaction of its elements with the burner and the boiler control system in order to provide the required capacities, efficiencies, and performance as specified.
2. Heat Exchanger: 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 1/2" or 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.

3. Each boiler shall be capable of operating with a minimum outlet water temperature of 68°F.

F. Exhaust Manifold

1. The exhaust vent must be UL listed for use with category III or IV appliance operating temperatures of up to 480° F, positive pressures, condensing flue gas service. Currently, UL listed vents of Polypropylene and AL29-4C stainless steel. Proper clearance to combustibles must be maintained per UL and vent manufacturer. The exhaust manifold shall have a gravity drain for the elimination of the condensation with collecting reservoir. The first plant shall Terminate above roof with exit cone provided with vent package. The second plant shall terminate through the wall and above grade with a 45° discharge velocity cone.
2. Exhaust Manifold: The exhaust manifold shall be of corrosion resistant cast aluminum or 316 stainless steel with the following diameter flue connections:
  - a) BMK2500 – 8 inch

G. Direct vent installation:

1. All combustion air is drawn from the outdoors to the units via metal or PVC ducts, see manufacturers recommendations

H. Boiler Controls: Refer to Division 23, Section “Instrumentation and Control of HVAC.”

1. The boiler control system shall be segregated into three components: “Edge” Control Panel, Power Box and Input/Output Connection Box. The entire system shall be Underwriters Laboratories recognized.
2. The control panel shall consist of six individual circuit boards using state-of-the-art surface-mount technology in a single enclosure. These circuit boards shall include:
  - a. A display board incorporating LED display to indicate temperature and a vacuum fluorescent display module for all message enunciation
  - b. A CPU board housing all control functions
  - c. An electric low-water cutoff board with test and manual reset functions
  - d. A power supply board
  - e. An ignition /stepper board incorporating flame safeguard control
  - f. A connector board

Each board shall be individually field replaceable.

3. The combustion safeguard/flame monitoring system shall use spark ignition and a rectification-type flame sensor.

4. The control panel hardware shall support both RS-232 and RS-485 remote communications.
5. The controls shall annunciate boiler and sensor status and include extensive self-diagnostic capabilities that incorporate a minimum of eight separate status messages and 34 separate fault messages.
6. The control panel shall incorporate three self-governing features designed to enhance operation in modes where it receives an external control signal by eliminating nuisance faults due to over-temperature, improper external signal or loss of external signal. These features include:
  - a. 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.
  - b. Setpoint Low Limit: Allow for a selectable minimum operating temperature.
  - c. 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 can to shut off the unit upon loss of external signal, if so desired.
7. The boiler control system shall incorporate the following additional features for enhanced external system interface:
  - a. System start temperature feature
  - b. Pump delay timer
  - c. Auxiliary start delay timer
  - d. Auxiliary temperature sensor
  - e. Analog output feature to enable simple monitoring of temperature setpoint, outlet temperature or fire rate
  - f. Remote interlock circuit
  - g. Delayed interlock circuit
  - h. Fault relay for remote fault alarm
8. 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.

9. Each boiler shall have an oxygen monitoring system that will measure the oxygen content of the exhaust gasses in real-time. Output of O<sub>2</sub> information shall be displayed on the C-More control panel.
10. 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:
  - a. Efficiently sequence 2-to-8 units on the same system to meet load requirement.
  - b. Integrated control and wiring for seamless installation of optional isolation 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, minimum of one must always stay open for recirculation.
  - c. Automatically rotate lead/lag amongst the units on the chain and monitor run hours per unit and balance load in an effort to equalize unit run hours.
  - d. Designated master control, used to display and adjust key system parameters.
  - e. Automatic bump-less transfer of master function to next unit on the chain in case of designated master unit failure; master/slave status should be shown on the individual unit displays.
  - f. Designated master control, used to display and adjust key system parameters.
11. For boiler plants greater than 8 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 +2°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:

- a. Manual designation of lead boiler and last boiler.
- b. Lead boiler rotation at user-specified time interval.
- c. 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.

MODBUS and BacNet protocols will be included with the Edge Controller to communicate with Building Management System.

## I. ELECTRICAL POWER

1. Controllers, Electrical Devices and Wiring: Electrical devices and connections are specified in Division 26 sections.
2. Single-Point Field Power Connection: Factory-installed and factory-wired switches, motor controllers, transformers and other electrical devices shall provide a single-point field power connection to the boiler.

## PART 3 – EXECUTION

### 3.1 INSTALLATION

- A. All aspects of installation of Boiler Plant shall be in strict accordance with manufacturer's instructions. The vent system *must conform to* all manufacturer's recommendations and shall utilize UL listed stainless steel AL-29-4C Positive Pressure. The vent must be sized in accordance with manufacturers recommendations.
- B. Boiler plant piping shall be field constructed of materials as specified. Each boiler shall have individually isolating shutoff valves for service and maintenance. Each boiler shall



require a minimum gas pressure of 3" W.C. 4000 scfh (full load rated capacity). Each boiler shall be provided with an individual supply gas regulator for proper gas regulation with a 2" NPT connection. Mechanical contractor to extend regulator vent to the outdoors.

C. Field Services

1. Contractor shall provide the services of a local factory authorized representative to supervise all phases of equipment startup. A letter of compliance with all factory recommendations and installation instructions shall be submitted to the engineer with operation and maintenance instructions.

D. Equipment Mounting:

1. Install boilers on cast-in-place concrete equipment base. Comply with requirements for equipment bases and foundation specified in Section 03 30 00 "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation devices specified in Section 23 05 48 "Vibration Controls for HVAC."
3. Manufacturer to provide removable casters to move boilers into place on units over 750 lbs.

E. Install gas-fired boilers according to NFPA 54, ANSI Z223.1 (United States)

F. Assemble and install boiler trim.

G. Install electrical devices furnished with boiler but not specified to be factory mounted.

H. Install control wiring to field mounted electrical devices.

I. Provide acid neutralizer tank for condensate line for each boiler. Acid neutralizer tank per manufacturers recommendations.

3.2 CONNECTIONS

A. Piping

1. Each boiler shall be provided with all necessary inlet and outlet connections. Refer to specific Boiler's specification sheet for connection sizes.
2. Check Manufacturer's Installation Manual for clearance dimensions and install piping that will allow for service and ease of maintenance.
3. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size.

B. Exhaust Venting

1. Install flue venting system per manufacturer's recommendations and state/provincial codes.

### 3.3 TRAINING

- A. Startup and training to be provided by a factory-trained service technician for a total of four (4) hours. These hours of training are to be "bankable hours" used within one full warranty year.
- B. All training and start-up shall be videotaped with a professional videographer and present two (2) copies of the training on DVD format to the Construction Manager within one (1) week of the training session. This DVD will be provided to the owner.

END OF SECTION 235222