

SECTION 23 52 16

CONDENSING BOILERS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the contract apply to this section, including General and Supplementary Conditions and Division 01 Specification Sections.

1.02 SUMMARY

- A. This section include packages, factory-fabricated and assembled, gas-fired, fire-tube and/or water-tube condensing boilers, trim and accessories for generating hot water.

1.03 SUBMITTALS

- A. Product Data: Include performance data, operating characteristics, furnished specialties and accessories.
 - A. Prior to flue vent installation, engineered calculations and drawings must be submitted to Architect/Engineer to thoroughly demonstrate that size and configuration conform to recommended size, length, and footprint for each submitted boiler.
- B. Efficiency Curves: At a minimum submit efficiency curves for 100%, 50% and 10% input firing rates at incoming water temperature ranging from 80 degrees F to 160 degrees F.
- C. Pressure Drop Curve: Submit pressure drop curve for each boiler size at the specific flow rate.
 - A. If submitted material is different from that of the design basis, boiler manufacture shall incur all costs associated with reselction of necessary pumps. Possible difference include, but are not limited to, the pump type, pump pad and size, electrical characteristics and piping changes.
- D. Shop drawings: For boilers, boiler trim and accessories include:
 - A. Plans, elevation, sections, details and attachment to other work
 - B. Wiring diagrams for power, signal and control wiring.
- E. Source Quality Control Test Reports: Reports shall be included in materials.
- F. Field Quality Control Test Reports: Reports shall be included in materials.
- G. Operation and Maintenance Data: Date to be included in boiler emergency, operation and maintenance manuals.
- H. Warranty: Standard warranty specified in this section
- I. Other Information Submittals:
 - A. ASME Stamp Certification and Report: Submit "H" stamp certificate of authorizaton, as required by authorities have jurisdiction and document hydronic testing of piping external to boiler.

1.04 QUALITY ASSURANCE

- A. Electrical components, Devices and Accessories: Boilers must be listed and labeleed 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 ahcieving the energy efficiency and performance ratings as tested within prescribed tolerances.
- C. ASME Compliance: Condensing boilers must be constructed in accordance with ASME Boiler and Pressure Vessel Code, Section IV "Heating Boilers."
- D. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency accodring to "Gas and Oil Fired Boilers – Minimum Efficiency Requirements."

- E. UL Compliance: Boilers must be tested for compliance with UL 795, “Commerical-Industrial Gas Heating Equipment.” Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction such as ETL.
- F. NOx Emission Standards: When installed and operated in accordance with manufactures instructions, the boiler shall comply with the NOx emisiion standards outlined in South Coast Air Quality Management District (SCAQMD), Rule 1146.1; and the Texas Commision on Enviroiromental Quality (TCEQ), Title 30, Chapter 117, and Rule 117.465 or the NOx emission referenced by the manufacutre for the specific boiler model.

1.05 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.

1.06 WARRANTY

- A. Standard Warranty: Boilers shall include manufactures standard form in which manufacture agrees to repair or replace (FOB) components of boilers that fail in materials or workmanship within specfied warranty period.
 - A. Warranty period for Fire-Tube and/or Water-Tube Condensing Boilers
 - a) The pressure vessel/heat exchanger shall carry a 10-year from date of shipment, non-prorated, limited warranty against any failure due to condensate corrosion, thermal stress, mechanical defects or workmanship.
 - b) All other components, with the exception of the igniter, flame detector and O2 sensor where applicable are conditionally guaranteed against any failure for (18) eighteen months from shipment. Local Sales Representative shall include warranty services labor for the duration of the (18) eighteen month warranty period. Extended warranty terms shall be offered by the manufacture prior to equipment purchase.

PART 2 PRODUCTS

2.01 MANUFACTURES

- A. Aerco Benchmark
- B. Lochinvar Crest
- C. Riello Array

2.02 CONSTRUCTION – FIRETUBE BOILERS

- A. Description: Boiler shall be either natural gas, propane, or dual fuel fired, fully condensing, fire tube design. Power burner shall have full modulation, discharge into a positive or negative pressure vent and the minimim firing rate shall not exceed the following per size range:
 - a) Input: 750-1000 MBTU/hr: 50,000 BTU/hr input minimum
 - b) Input: 1500 MBTU/hr: 75,000 BTU/hr input minimum
 - c) Input: 2000 MBTU/hr: 100,000 BTU/hr input minimum
 - d) Input: 2500 MBTU/hr: 167,000 BTU/hr input minimum
 - e) Input: 3000 MBTU/hr: 200,000 BTU/hr input minimum
 - f) Input: 5000-6000 MBTU/hr: 400,000 BTU/hr input minimum

Boilers that have an input greater that what is specified above at minimum fire will not be considered. 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.
- B. 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 ½” or 5/8” OD with no less that 0.049” wall thickness. The upper and lower stainless steel tubesheet shall be no less that 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-inches diameter.

C. Pressure Vessel: The boiler water pressure drop shall not exceed the following per size:

- A. 750-1000 MBTU/hr: 3 psig @ 100 gpm
- B. 1500-2000 MBTU/hr: 3 psig @ 170 gpm
- C. 2500 MBTU/hr: 3 psig @ 218 gpm
- D. 3000 MBTU/hr: 3 psig @ 261 gpm
- E. 5000/6000 MBTU/hr: 4 psig @ 500 gpm

The boiler water shall be 3-inch (750-1000 MBTU/hr), 4-inch (1500-3000 MBTU/hr), or 6-inch (5000-6000 MBTU/hr) flanged 150-pound, ANSI rated. The pressure vessel shall be constructed of ASME 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.

D. Modulating Air/Fuel Valve and Burner: the boiler burner shall be capable of high 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 20 ppm of NO_x, 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 for the optimum mixing of air and fuel between the air/fuel valve and the burner.

E. Dual Fuel Capacity: If dual fuel is required (natural gas/propane), the boiler shall include a combustion system with dual fuel capability. The dual fuel unit shall be capable of operating on both natural gas and propane. The boiler efficiency and turndown shall remain unchanged regardless of fuel source. The dual fuel system shall incorporate independent natural gas and propane gas trains and a fuel selector switch. This switching mechanism shall be such that it shall not be possible to flow both fuels simultaneously. The unit shall be calibrated to run on both fuel sources at start-up. No additional re-calibration shall be required when switching between fuel sources for a period of one year from the initial calibration.

F. Exhaust Manifold: The exhaust manifold shall be of corrosion resistant cast aluminum or 316 stainless steel with the following diameter flue connections:

- A. 750-1500 MBTU/hr: 6-inch
- B. 2000-3000 MBTU/hr: 8 inch
- C. 5000 MBTU/hr: 12 inch or 14 inch
- D. 6000 MBTU/hr: 12 inch (<20 ppm NO_x) or 14 inch (<9 ppm NO_x)

The exhaust manifold shall have a collecting reservoir and a gravity drain for the elimination of condensation.

G. Blower: the boiler shall include a variable-speed, DC centrifugal fan to operate during the burner firing sequence and pre-purge the combustion chamber.

H. Motors: Blower motors shall 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 a motor to operate in the service factor range above 1.0.

I. Ignition: Ignition shall be via spark or proven pilot ignition with 100 percent main-valve shutoff and electronic flame supervision.

J. 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.

- K. The boiler shall incorporate an air filter to filter the combustion air prior to it entering the blower assembly.
- L. Enclosure: The plastic and sheet metal enclosure shall be fully removable, allowing for easy access during servicing. Main access panels shall be removable without the need for tools.

2.03 CONTROLS – FIRETUBE BOILERS

- A. Refer to Division 23, Section “Instrumentation and Control of HVAC.”
- B. The entire boiler control system shall be Underwriters Laboratories recognized.
- C. The control panel shall consist of individual circuit boards using state-of-the-art surface-mount technology in a single enclosure. Each board shall be individually field replaceable without requiring special software programs or interfacing with a PC.
- D. The combustion safeguard/flame monitoring system shall use spark or proven pilot ignition and a rectification-type flame sensor.
- E. The control panel hardware shall support RS-485 remote communications.
- F. The controls shall announce boiler and sensor status and include extensive self-diagnostic capabilities that incorporate a minimum of eight separate status messages and 52 separate fault messages.
- G. The control panel shall incorporate three self-governing features designed to enhance operation in external control modes. When operating by an external control signal, the control panel can work to eliminate nuisance faults such as over-temperature, resulting from improper external signal or loss of external signal. These features include:
 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 can to shut off the unit upon loss of external signal, if so desired.
- H. The boiler control system shall incorporate the following additional features for enhanced external system interface.
 1. Outside Air Reset Control with optional sensor.
 2. Analog input for set point control (0-5 vdc or 1-5 vdc) (0-20 ma or 4-20 ma)
 3. Auxiliary start delay timer
 4. Remote interlock circuit
 5. Delayed interlock circuit
 6. Fault relay for remote fault alarm
- I. 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.
- J. Each boiler shall have integrated software capable of multi-unit sequencing with lead-lag functionality and parallel operation. The system will incorporate the following capabilities:
 1. Efficiently sequence 2 to 8 units on the same system to meet load requirement.
 2. 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, with all opening under no-load condition.
 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 unit run hours.
 4. Option to manually designate lead and last boiler.

5. Designated master 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 (with optional network header sensor); master/slave status should be shown on the individual unit displays.

2.04 CONSTRUCTION – WATERTUBE BOILERS

- A. Description: Boiler shall be wither natural gas or propan fired, fully condensing, water tube design. Power burner shall have full modulation, discharge into a positive or negative pressure vent and the minimum firing rate shall not exceed the following per size range:
 - a) Input: 1000 MBTU/hr: 100,000 BTU/hr input minimum
 - b) Input: 1500 MBTU/hr: 100,000 BTU/hr input minimum
 - c) Input: 2000 MBTU/hr: 100,000 BTU/hr input minimum
 - d) Input: 3000 MBTU/hr: 100,000 BTU/hr input minimum
 - e) Input: 4000 MBTU/hr: 100,000 BTU/hr input minimum

Boilers that have an input greater that what is specified above at minimum fire will not be considered. Boiler efficiency shall increase with decreasing load (output), while maintaining setpoint. Boiler shall be factory-fabricated, factory-assembled and factory- tested, water-tube condensing boiler with heat exchangers 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.

- B. Heat Exchangers: Each boiler shall consist of mulitple, individual stainless-steel (AISI 316L) water tube heat exchangers. Each heat exchanger shall be 500,000 BTU/hr input each and shall be independent of one another. The heat exchangers shall be of a dual helical coil design which consists of a single continous tube, connected only at the ends. Coils with multiple tubes or multiple connections to a common manifold will not be accepted. The heat exchanger shall have a water-backed reservoir on each end of the helical coils. Such reservoirs shall allow expansion and contraction of the coil with minimal mechanical stress. The water tube shall have a minimum equivalent diameter of 1-inch. To reduce the possibility of internal scaling, the helical coil shall have a water velocity of at least 1.8 ft/s. The heat exchangers shall be built and tested in accordance with ASME Section IV snd hseve a MAWP of 80 psi. the heat exchangers shall be of welded construction, no gaskets. Each heat exchanger shall prvide 43sf.ft/500,000 BTU/hr of heating surface and shall be individually replaceable without isolating the entire boiler.
- C. Combustion Chamber: The combustion chamber shall be 316L or 316Ti stainless- steel. Carbon steel combustion changers will not be accepted. A window view port shall be provided for visual inspection fo the boiler combustion during firing.
- D. Pumps: Each module shall have its own internal wet rotor circulatin pump. The onboard boiler control panel shall stage these pumps with the modules as described below in lead/lag staging. Each module shall also have its own flow meter to monitor the status of its pump. Boilers requiiring singular, or externally mounted primary pumps will not be accepted.
- E. Gas Trains: The main boiler gas train shall incorporate a low and high gas pressure switch. Each individual heat exchanger (module) shall have its own zero governing, dual safety shut off gas valve. Each module shall also have its own manual gas shut off valves upstream and downstream of the automatic gas valve.
- F. Burners: The burners shall be of a premix design wit ha stainless-steel knitted metal fiber mesh. Ceramic or non-metallic burners will not be accepted. Each burner shall operate with a 5:1 turndown, per module in a fully modualting fashion. Stepped or staged modulation will not be accepted.
- G. Emissions: The burners shall not produce more that .04% of carbon monoxide at all firing rates. The burner shall be certified for NOx readings of <9ppm corrected to 3% oxygen.
- H. Ignition: Ignition shall be via direct spark with 100 percent main-valve shutoff and electronic flame supervision.
- I. The boiler shall be desinged 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.

- J. Enclosure: The sheet metal enclosure shall be fully removable, allowing for easy access during servicing. Main access panels shall be removable without the need for tools.

2.05 CONTROLS – WATERTUBE BOILERS

- A. Refer to Division 23, Section “Instrumentation and Control of HVAC.”
- B. The entire boiler control system shall be UL or ETL recognized.
- C. The control panel shall consist of individual circuit boards. Each board shall be individually field replaceable without requiring special software programs or interfacing with a PC.
- D. The combustion safeguard/flame monitoring system shall use spark ignition. The spark igniter shall also double as the rectification-type flame sensor.
- E. The control panel hardware shall support the RS-485 remote communications.
- F. Each module shall have its own flame safeguard/controller to allow for shutdown of an individual module without shutting down the entire boiler.
- G. The boiler shall incorporate a service display for service personnel (password protected). And a 7” color touchscreen for the general boiler operator. Each shall provide full diagnostics including real time data logging, error history and current operating status/data. Both the service display and the touchscreen are intended for annunciation purposes only and shall not be control devices. In the event of failure, the boiler shall operate without the service panel or touchscreen in place.
- H. The boiler control system shall incorporate the following additional features for enhanced external system interface:
 - A. Outside Air Reset Control with sensor installed
 - B. Analog input for set point control (0-10vdc)
 - C. Air damper control
 - D. Enable/Disable
 - E. Fault relay for remote fault alarm
 - F. System/Secondary pump control
 - G. Individual flow monitoring and pump control per module
- I. Each boiler shall have integrated software 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 boilers (2-64 modules) on the same system to meet load requirements.
 - B. Automatically rotate lead/lag amongst the boilers on the chain and the modules within the boilers.
 - C. Designated master control, used to display and adjust key system parameters
 - D. Failsafe/Emergency Mode to allow for standalone boiler operation in the event of communication failure or system sensor failure.
 - E. Automatic set point calculation to maintain secondary loop temperature without prematurely staging modules and with varying flows

2.06 ELECTRICAL POWER

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

2.07 VENTING

- A. The exhaust vent must be UL listed for use with Category II, III, and IV appliances and compatible with operating temperatures up to 230 degrees F, condensing flue gas service. UL-listed vents of Polypropylene and A1 29-4C stainless steel must be used with boilers.

- B. The minimum exhaust vent duct size for each boiler is six-inch (750-1500 MBTU/hr), 8-inch (2000-3000 MBTU/hr), 10-inch (4000 MBTU/hr) or 12-inch (5000-6000 MBTU/hr) diameter.
- C. 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.
- D. The minimum ducted combustion air duct size for each boiler is six-inch (750-1500 MBTU/hr), 8-inch (2000-3000 MBTU/hr), 10-inch (4000 MBTU/hr) or 12-inch (5000-6000 MBTU/hr), or 14-inch (5000-6000 MBTU/hr) diameter.
- E. 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.

2.08 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 testing.
- B. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.
 - a. 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 Architect 14 days in advance of testing.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Before boiler installation examine roughing-in for concrete equipment bases, anchor-bolt sizes, locations, 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.

3.02 INSTALLATION

- A. Install boilers level on concrete bases. Concrete base is specified in Division 23 Section "Common Work Results for HVAC," and concrete material and installation requirements are specified in Division 03. The rear of each boiler shall be flush with the concrete base "house keeping pad" to insure proper gravity drainage of condensate.
- B. Install gas-fired boilers according to NFPA 54.
- C. Assemble and install boiler trim per manufacturer's recommendations.
- D. Install electrical devices furnished with boiler but not specified to be factory mounted.
- E. Install control wiring to field-mounted electrical devices.
- F. Install a condensate neutralizer manufactured by BKI Industries or equivalent for each boiler. Condensate drain piping shall be of PVC/CPVC or stainless-steel material. Unions shall be installed upstream and downstream of condensate neutralizer to allow for ease of maintenance.

3.03 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 permit service and maintenance.

- C. Install piping from equipment drain connection to nearest floor drain. Piping shall be a least full size of connection. Provide an isolation valve if required.
- D. Connect gas piping to boiler gas-train inlet with unions. Piping shall be at least full size of gas train connection. Provide a reducer if required. An appropriate shutoff valve shall be installed at each boiler and shall be operable without the use of ladders, steps or tools.
- E. Connect hot-water piping to supply and return boiler connection with shutoff valve and union or flange at each connection.
- F. Install piping from safety relief valves to nearest floor drain.
- G. Boiler Venting:
 - A. Install venting using the vent manufacturers appliance adaptor for the specific boiler model being installed. Modifications to universal adaptors or standard vent lengths will not be accepted.
 - B. Connect venting full size to boiler connections. (Comply with requirements in Division 23 Section “Breechings, Chimneys and Stacks.”)
- H. Ground equipment according to Division 23 Section “Grounding and Bonding for Electrical Systems.”
- I. Connect wiring according to Division 23 Section “Low-Voltage Electrical Power Conductors and Cables.”
- J. When installed, Enable/Disable relay(s) shall be accessible without removing the boilers sheet metal or using ladders. The relay(s) shall incorporate HOA switched and indicator lights.
- K. Emergency Power Off (EPO) switches shall be installed at each exit point of the room where the boiler is being installed. RGe EPO switched/relays shall break line/control power to the boilers internal controllers to prohibit the gas valves from being energized.

3.04 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
 - 1. Manufacture’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 manufacture’s written instructions.
 - 2. Perform hydrostatic test. Repair leaks and retest until no leaks exist.
 - 3. Start units to confirm proper motor rotation and unit operations. 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 point and high-and low-limit safety set points of fuel supply, water level and water temperature.
 - b. Set field-adjustable switched and circuit-breaker trip ranges as indicated.
- C. Remove and replace malfunctioning units and retest as specified above.
- D. Occupancy Adjustments: When requested within 2 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. The boiler manufacture is expected to provide partial load thermal efficiency curves. These thermal efficiency curves must include at least three separate curves at various BTU input levels. If these curves are not available, it is the responsibility of the boiler manufacturer to complete the following performance tests:
 - 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
 - i. Test for full capacity
 - ii. Test for boiler efficiency at (low fire, 20, 40, 60 80, 100, 80, 60, 40, and 20)percent of capacity. Determine effieiciency at each test point.
- F. Repeat test until results comply with requirements indicated.
- G. Provide analysis equipment required to determine performance.
- H. Provide temporary equipment and system modifications necessary to dissipate the heat produced during test if building systems are not adequate.
- I. Notify architect in advance of test dates.
- J. Document test results in a report and submit ot architect.

END OF SECTION 23 52 16