

SECTION 23 52 39
FIRE-TUBE BOILERS

PART 1 - GENERAL

1.1 DESCRIPTION:

This section specifies packaged fire tube boiler with trim (accessories), dual fuel (natural gas and No. 2 oil) burner, fuel valve and piping trains, flue gas economizer, and other accessories.

1.2 RELATED WORK:

- A. Section 09 91 00, PAINTING.
- B. Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT and STEAM GENERATION.
- C. Section 23 05 51, NOISE and VIBRATION CONTROL FOR BOILER PLANT.
- D. Valves for boiler trim, non-return stop-check valves, blowoff valves, piping for fuel and feedwater valve trains: Section 23 21 11, BOILER PLANT PIPING SYSTEMS.
- E. Boiler outlet damper systems, breechings, stacks, flue gas recirculation (FGR) ductwork: Section 23 51 00, BREECHINGS, CHIMNEYS, and STACKS.
- F. Controls, pressure gages, thermometers: Section 23 09 11, INSTRUMENTATION and CONTROL FOR BOILER PLANT.
- G. Section 23 08 11, DEMONSTRATIONS and TESTS FOR BOILER PLANT.
- H. Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS. Requirements for commissioning, systems readiness checklists, and training
- I. Section 23 08 12, VA Boiler Plant Safety Device Testing Manual, Third Edition, 2008 for testing and safety device requirements for natural gas and fuel oil trains.

1.3 QUALITY ASSURANCE:

- A. Coordinate all new and existing equipment and conditions. This includes, but is not limited to: boiler, boiler trim, burner, fuel valve and piping trains, gas pressure regulators and available gas pressure, required fuel oil train pressures and fuel oil header back pressure regulator on house oil pump set, compressed air system for oil atomization, control systems, economizer, breeching and stacks.
- B. Provide written certification that the entire assembly has been coordinated to achieve the required performance and to provide the required features.
- C. The model and size of the proposed burner shall have been applied to at least three fire tube boilers which are similar in size, proportion, number of passes and furnace dimensions to the proposed boiler. In each of the three installations, burner performance shall have conformed to

requirements specified in the Subparagraph, "Performance" under the Article, BURNER, AND FUEL TRAINS of Part 2. Provide list of these installations, and name, address, and telephone number of person familiar with each project who will serve as a reference source.

- D. Regardless of fuel input rating, the equipment, installation and operation shall conform to NFPA 85. Where conflicts exist between NFPA 85 and this specification, this specification will govern.
- E. All work, including installation and testing, shall be completed in accordance with the requirements described in the VA Boiler Plant Safety Device Testing Manual, Third Edition (2008), which forms a part of this specification by reference, and is included.

1.4 SUBMITTALS:

- A. Before executing any work, submit in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.
- B. Boiler:
 - 1. Complete catalog information and outline drawings of boiler, burner, and accessories with dimensions including tube removal space and access door opening space.
 - 2. Catalog cuts showing arrangement and construction of pressure parts, casing, internals, and support frame.
 - 3. Piping connection sizes, locations, types (threaded or flanged).
 - 4. Technical data including temperature rating and arrangement of refractory and insulation.
 - 5. Steam nozzle construction. Capability of steam nozzle and attachment to boiler shell to withstand forces and moments imposed by connecting piping.
 - 6. Amount of heating surface and combustion volume.
 - 7. Weight of boiler empty and flooded including burner and boiler and burner accessories.
 - 8. Design pressures and temperatures.
 - 9. Loading diagram of support frame. Evidence that boiler support requirements have been coordinated with foundation design.
 - 10. Recommended anchorage of boiler support frame to foundation.
 - 11. Furnace viewport construction, locations.
 - 12. Dimensioned location of normal water line, lowest and highest permissible water level, set points of water level alarms and cutoffs.

13. Predicted external surface temperature of front, rear and sides of boiler.
- C. Boiler Trim: Includes bottom blowoff valves, water level alarm and cutoff devices, water level gage, low water cutoffs, piping, all valves and fittings furnished by boiler manufacturer, feedwater control system, steam safety valves, steam pressure gage, stack thermometer, draft gage, and steam pressure switches.
 1. Design, construction, arrangement on the boiler.
 2. Pressure and temperature limitations.
 3. ASTM numbers and schedule numbers of piping.
 4. Type and pressure ratings of pipe fittings.
 5. Flow and pressure drop data on feedwater regulating valves.
 6. Technical data on water level control system.
 7. Scale ranges of gages, thermometers and pressure switches.
 8. Location of water level sensing and indicating device set points in relation to normal water line and lowest and highest permissible water levels of boiler.
 9. Set pressure and capacity of safety valves.
- D. Burner and Fuel Valve and Piping Trains:
 1. Catalog data and drawings showing burner assembly and fuel train arrangement.
 2. Outline drawings of flue gas recirculation (FGR) ductwork (if applicable).
 3. Outline drawings of sound attenuators on forced draft fan intake or discharge.
 4. Drawings showing assembly of throat refractory into furnace.
 5. Type and temperature rating of throat refractory.
 6. Drawings and catalog data on all equipment in igniter (pilot) train, main fuel trains, and atomizing media train. Include data on pressure and temperature ratings, flow versus pressure drop, performance characteristics. Include complete data on air compressors (for oil atomizing) with sound attenuators and motors.
 7. ASTM numbers and schedule numbers on all piping.
 8. Type and pressure ratings of pipe fittings.
 9. Burner flow and pressure data:
 - a. Main burner fuel and atomizing air pressures and flows at maximum required firing rate.
 - b. Igniter (pilot) fuel flow and burner pressure.

- c. Natural gas main fuel pressure at inlet and outlet of main burner pressure regulator.
- d. Igniter (pilot) fuel pressures (natural gas and LP gas) at inlet and outlet of burner-mounted pressure regulators.
- e. Forced draft fan static pressure, power and air flow at maximum firing rate.
- f. Oil pressure required at boiler fuel oil pump inlet (if applicable).
- 10. Full load efficiency and power factor of all motors.
- 11. Predicted sound level at maximum firing rate on each main fuel.
- 12. Weight of burner assembly.
- E. Burner Management (Flame Safeguard) System: Refer to Section 23 09 11, INSTRUMENTATION and CONTROL FOR BOILER PLANT.
- F. Flue Gas Economizer:
 - 1. Drawings showing arrangement and dimensions of unit and all accessories.
 - 2. Design and construction of unit and accessories including soot blowers and safety relief valve. Written recommendations of soot blower manufacturer on type and quantity of soot blowers.
 - 3. Weight of entire unit, empty and flooded.
 - 4. Pressure and temperature limitations of unit and accessories.
 - 5. Performance data on safety relief valve.
 - 6. Manufacturer's support requirements.
- G. Boiler, Burner, Economizer Predicted Performance Data:
 - 1. At Maximum Required Output: On each fuel at site altitude, with and without economizer (if applicable) in service, at 15 percent excess air. Data must include fuel and steam flow, boiler flue gas outlet temperature, economizer (if provided) flue gas outlet temperature, steam quality, boiler efficiency, windbox and furnace pressures, predicted boiler radiation and unaccounted losses, feedwater and flue gas pressure losses in the economizer.
 - 2. At low fire, 25%, 50%, 75% of Maximum Required Output. Excess air, CO ppm, NOx ppm on each fuel.
- H. ASME "P" Forms, Manufacturer's Data Report, on boiler and economizer construction - submit after boiler and economizer are fabricated.
- I. Pretest Data - Boiler, Burner, Controls: As required by Part 3.
- J. Completed System Readiness Checklists provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician

and dated on the date of completion in accordance with the requirements of Section 23 08 00 COMMISSIONING OF HVAC SYSTEMS.

1.5 PROJECT CONDITIONS

- A. Fuels to be Fired, Main Burner: Natural gas, No. 2 fuel oil.
- B. Igniter (Pilot) Fuels: Natural Gas and LP gas (propane).
- C. Natural Gas: High heating value is reported as 1000 Btu per cubic foot at gas company base pressure and temperature. Pressure provided to the inlet of the boiler-mounted regulators will be 7-10 psi gage as maintained by main regulator station.
- D. Fuel Oil: Will be furnished under Government contract. House pumping system is designed to provide 110 psi gage nominal to the fuel train entrance on each burner. Pressure will vary in accordance with characteristics of backpressure regulator on oil pump set (Refer to Section 23 50 11, BOILER PLANT MECHANICAL EQUIPMENT. Oil grade (No. 2) refers to ASTM D396. No burner-mounted pump or relief valve is required.
- E. Oil Atomizing Media: Low-pressure air atomizing burners are required and each boiler must include a dedicated air compressor system furnished by burner manufacturer.
- F. LP Gas: Propane furnished directly to the Government for igniter (pilot) fuel by a local supplier. Regulators at tank area will be set at 5 psi gage. Serves as igniter fuel when there is an interruption to the natural gas supply.

1.6 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by basic designation only.
- B. ASTM International (ASTM):
 - A106/A106M-08.....Standard Specification for Seamless Carbon Steel Pipe for High Temperature Service.
 - A178/178M-02(2007).....Standard Specification for Electric-Resistance-Welded Carbon Steel and Carbon-Manganese Steel Boiler and Superheater Tubes
 - A269-10.....Standard Specification for Seamless and Austenitic Welded Stainless Steel Tubing for General Service
 - C612-10.....Standard Specification for Mineral Fiber Block and Board Thermal Insulation
 - D396-09a.....Standard Specification for Fuel Oils

- C. American Society of Mechanical Engineers (ASME):
Boiler and Pressure Vessel Code - 2007 Edition with Amendments.
Section I.....Power Boilers
Section II.....Material
Section VII.....Recommended Rules for Care of Power Boilers
Section IX.....Welding and Brazing Qualifications
Performance Test Code (PTC):
PTC 4-2008.....Fired Steam Generators
Code for Pressure Piping:
B31.1-2007.....Power Piping
- D. National Fire Protection Association (NFPA):
85-2007.....Boiler and Combustion Systems Hazards Code.
- E. Underwriters Laboratories (UL):
50-2007.....Enclosures for Electrical Equipment
- F. Department of Health and Human Services, Food and Drug Administration
(FDA):
CFR 21, 173.310, Boiler Water Additives Permitted in Plants Where Steam
Contacts Food
- G. Environmental Protection Agency (EPA):
CFR 40, PART 60, Appendix A, Method 9, Visual Determination of the
Opacity of Emissions from Stationary Sources

PART 2 - PRODUCTS

2.1 BOILER:

- A. Type: Factory-assembled packaged Scotch marine horizontal fire tube high pressure steam boiler. Four pass wet back design with internal furnace located below center of boiler shell. Designed for natural gas and No. 2 fuel oil firing.
- B. Service: Continuous long term generation of steam throughout the burner firing range in conformance to the specified performance requirements with feedwater supply at 212 degrees F.
- C. Performance:
1. Steam Output Quantity and Pressure: Refer to schedules on drawings.
 2. Steam Output Quality: 99 percent minimum at all steam flow rates.
Based on water quality in boiler of 2200-ppm maximum total solids, 15-ppm maximum suspended solids, 440-ppm maximum alkalinity.
 3. Minimum Efficiency at Required Maximum Output:
 - a. Natural Gas Fuel 1000 Btu/cu. ft.: 82 percent at 15 percent excess air.

- b. Fuel Oil (ASTM D396, Grade 2): 85 percent at 15 percent excess air.
- D. Heating Surface: Heating surface is defined as the fireside area of the furnace and combustion chamber plus inside (gas side) circumferential area of all convection tubes. Minimum surface shall be 5 square feet per boiler horsepower.
- E. Design Pressure: 200 psi gage. Purpose of high design pressure is to provide additional corrosion allowance.
- F. Construction:
 - 1. Codes: Comply with ASME Boiler and Pressure Vessel Code, Sections I, II, VII, and IX.
 - 2. Tubes: ASTM A178 Grade A, smooth wall inside and outside. Minimum thickness 0.105 inches. Flue gas spinners or turbulators are not allowed.
 - 3. Manway: Cover and yokes shall be forged steel. Manway shall seal tight with no leakage. Provide non-asbestos gaskets.
 - 4. Handholes: Covers and yokes shall be forged steel. Handholes shall seal tight with no leakage. Provide non-asbestos gaskets.
 - 5. Access to Tubes and Furnace: Provide hinged and davited doors and access panels to permit access to all tubes and furnace for cleaning, repairs and replacement. Doors wider than the radius of the boiler shell shall be davited and shall be operable by one person. Hinges or davits are not required for access panels less than 610 mm (two feet) in width and height. All doors and panels shall have non-asbestos gaskets and shall be sealed tight with capscrews threaded into brass nuts. Panels shall have handles.
 - 6. Shell Piping Connections: Flanged, except threaded is permitted for pipe sizes under 65 mm (2-1/2 inches). Connections shall include, but not be limited to:
 - a. Steam nozzle shall be 2050 kPa (300 psi) ASME flanged. Design nozzle and shell assembly to withstand forces and moments imposed by connected piping. Studding nozzle will not be permitted.
 - b. Locate manual steam vent on top of boiler shell to permit access to vent gate valve from platform located above boiler.
 - c. Locate safety valve outlets to permit straight run of vents through roof and to permit valve handle access from platform located above boiler.

- d. Connections for water level control, alarm and indication devices.
 - e. Connections for boiler feed water, chemical admission, combined continuous blowdown and water sampling. Locate below normal water level and as shown.
 - f. Bottom blowoffs. Locate to permit complete collection of sediment and complete drainage.
 - g. Pressure gage and pressure switch connections. (May be connected to water level controller steam piping.)
7. Support System: Provide proper support of all elements of the boiler, burner, and accessories during shipment, rigging, and in final installation. Arrange supports to permit thermal expansion and to resist seismic shocks (in seismic areas). No element of the boiler or accessories shall be overstressed, displaced, have cracks, broken welds, or excessive deflection. All vertical elements of the boiler and accessories shall be plumb, and all horizontal elements shall be level.
- a. Base Frame: Design for mounting on flat concrete base. All elements shall be level. Provide attachments for anchorage to the concrete foundation.
 - b. Rigging and Jacking: Provide lifting lugs and provisions for jacking. Painted stencils shall identify jacking locations.
 - c. Platform Support Brackets: Provide brackets attached to boiler shell to support field-installed valve and manway access catwalk alongside top of boiler. Catwalk shall provide maintenance access to non-return valve, safety valves, economizer feedwater valves, and economizer access door.
 - d. Economizer Support Brackets: Provide brackets attached to boiler shell to support field-installed economizer at top of boiler.
8. Refractory and Insulation: Boiler manufacturer's standard and experience proven design except insulation on the boiler shell shall be a minimum of 50 mm (two inches) thick. No part of the external casing shall exceed 33 degrees C (60 degrees F) above ambient, except for areas within 300 mm (one foot) of the casing penetrations.
9. Casing: Sheet steel covering all areas of boiler shell. Flash or seal all openings at top of boiler at piping and flue connections to prevent leakage of water into insulation. Provide a 300 mm (one

- foot) minimum width section of heavy gage reinforced casing or heavy density insulation (minimum 96 kg per cubic meter, six pounds per cubic foot) along the top centerline of the entire length of the boiler to permit walking on top of the boiler without denting the casing.
10. Observation Port: Provide single port at rear of furnace located to permit flame observation. Furnish with one clear and one tinted interchangeable heat resisting glass, gas-tight operable metal closure between furnace and glass, forced air cooling to reduce moisture condensation on glass.
- G. Factory Inspection and Certification: Inspect the completed boiler assembly in accordance with the requirements of the ASME Boiler and Pressure Vessel Code, Section I, RULES FOR CONSTRUCTION OF POWER BOILERS. The boiler inspection shall be certified. Submit four copies of ASME Form P-2 for each boiler.
- H. Finish: Provide surface preparation, heat-resistant prime and finish coats using standard color of the boiler manufacturer. Refer to Section 09 91 00, PAINTING.

2.2 BOILER TRIM (ACCESSORIES):

- A. Conform to ASME Boiler and Pressure Vessel Code, Section I
- B. Steam Safety Valves:
1. Capacities certified by National Board of Boiler and Pressure Vessel Inspectors (NB).
 2. Type: Bronze or cast iron bodies, side outlet, flanged or threaded inlet and outlet, lifting lever, dual control rings, stainless steel trim, o-ring EPDM seats on bronze valves.
 3. Settings and Adjustments: Factory set, sealed, and stamped on nameplate. Set pressures as shown. Set pressure of lowest pressure valve shall not exceed normal boiler plant operating pressure by more than 210 kPa (30 psi). Provide 30 kPa (5 psi) difference in setting between each of the valves.
- C. Steam Pressure Gage:
1. Case: Turret-style, bottom connection, threaded ring, blowout disc in rear.
 2. Dial: 200 mm (8 inch) minimum diameter, non-corrosive, black markings on white background.
 3. Measuring Element: Bourdon tube designed for steam service.
 4. Movement: Stainless steel, rotary.

5. Pointer: Micrometer adjustable, black color.
6. Window: Laminated safety glass, or plastic.
7. Accuracy: One half percent of the full span.
8. Range: 0 - 300 psi gage.
9. Installation: Stop valve, steel piping, valved blowdown, siphon, union at gauge, valved connection for inspector's gauge. Refer to Detail, FIRETUBE BOILER.

D. Water Level Safety and Operating Controls and Indicators:

1. Provide high and low water warning alarms, primary and auxiliary low water burner cutoffs, automatic electronic modulating feedwater level control system, gage glass.
 - a. High and low water warning alarms shall operate bell and separate high and low water level indicating lights on boiler control panel and shall not shut down the burner. High alarm condition shall operate and annunciate whether burner is ON or OFF.
 - b. Primary and auxiliary low water burner cutoff devices shall be in two separate water columns, piped individually to the boiler water spaces. One device shall be float-type, the other device shall be conductivity probes. Primary and auxiliary cutoffs shall require manual reset. Auxiliary cutoff shall shut down power to the burner management system. Non-latching shunt switches shall allow blowdown of water columns without shutting down the burner.
 - c. Water level set points for all devices shall be as recommended by boiler manufacturer.
 - d. Water level control system shall maintain the water level within limits established by boiler manufacturer for normal water level with no tripping of high and low level alarms with instantaneous load swings of 25 percent of boiler capacity. Feedwater pump will operate continuously.
 - e. Refer to Section 23 09 11, INSTRUMENTATION and CONTROL FOR BOILER PLANT for detailed operation of all indication, monitoring, alarm and control devices.
2. Water Column Unit with Water Level Controller, Gage Glass, Water Level Sensor for Primary Low Water Cutoff:
 - a. Float-type electric water level control device and primary low water cutoff.

- b. Height of water column and gage glass shall be sufficient to show water level in the gage glass at least 12 mm (0.5 inches) above high water alarm set point and at least 12 mm (0.5 inches) below auxiliary low water cutoff set point.
 - c. Control system shall automatically modulate an electric feedwater flow control valve. Feedwater pump will operate continuously.
 - d. Gage Glass and Gage Valves: Single vertical tubular gage glass, tempered borosilicate, red line, rated for 315 degrees C (600 degrees F). Provide automatic off-set gage valves with ball checks to prevent fluid flow if gage breaks. Provide gage rods to protect glass.
3. Auxiliary Water Column with Water Level Sensors for High and Low Level Alarms and Auxiliary Low Water Cutoff:
- a. Conductivity probe type high and low level alarm sensors and auxiliary low water cutoff sensor.
 - b. UL listed, factory-built probe and chamber unit mounted externally from the boiler.
 - c. Stainless steel conductivity probes and grounding probe. Virgin Teflon insulation.
4. Water columns shall be rated for 1400 kPa (200 psi) minimum saturated steam and have boiler and drain connections.
5. Water Column Piping to Boiler and to Drains: ASTM A106 Grade B, seamless or ERW piping, Schedule 80 threaded. Fittings shall be 300 lb. malleable iron or forged steel. All changes in direction shall be with crosses, no ells. Provide valved drain piping connected to the lowest part of each of the water columns.
6. Electrical: Provide circuit breakers, transformers, all devices for complete control system. All control electronics and relays shall be in waterproof NEMA 4X panels.
7. Modulating Feedwater Control Valve:
- a. Characterized rotary or sliding gate valve. Operated by electric drive unit actuator with top mount integrated digital positioner. Equal-percent valve flow characteristics. Modified linear valve flow characteristics shall be utilized when digital positioner is furnished.
 - b. Performance: Refer to schedules on the drawings for pressure, temperature and flow requirements. If not shown on the drawings, the valve shall be designed for maximum flow rate of 125% of the

maximum boiler steam output with 70 kPa (10 psi) pressure drop, maximum inlet pressure of 2000 kPa (300 psi), maximum temperature of 138 °C (280 °F). Shut-off seat leakage less than 0.0001 percent of valve CV.

- c. Rotary Valve: Three-piece carbon steel body, 316 SS ball and stem, Polyfil seat, TFE coated SS seal, 2000 kPa (300 psi) 138 °C (280 °F) minimum ratings. Flanged ends or wafer type for pipe sizes over 50 mm (2 inches), threaded ends for pipe sizes 50 mm (2 inches) and under.
 - d. Sliding Gate Valve: Stainless steel body, head section, actuator springs valve stem and fixed disc. Triballoy (STN2) self-aligning sliding disc. Carbon filled PTFE packing. Minimum ratings 2000 kPa (300 psi), 138 degrees C (280 degrees F).
 - e. Sound Levels: Conform to Section 23 05 51, NOISE AND VIBRATION CONTROL FOR BOILER PLANT.
 - f. Electric Drive Unit for Rotary Valve: Shall have sufficient power to operate valve under all operating conditions. All parts of linkage between drive unit and valve shall be free-working, securely attached, and shall not distort under all operating conditions.
8. Shunt Switches for Primary Low Water Cutoff and Auxiliary Low Water Cutoff: Provide separate non-latching shunt switches for each of the low water cutouts to allow manual blowdown of water column without tripping burner. Locate each switch adjacent to the drain valve for the low water cutout that is affected by the switch.
9. Low Water Cutout Operation: Manual reset of primary low water cutoff shall be combined with the burner management manual reset. The burner management system annunciator and associated alarm horn shall indicate the primary and auxiliary low water cutoff operation. Operation of auxiliary low water cutoff shall shut down power to burner management system.
- E. Stack Thermometer: Dial-type, bi-metal element, stainless steel case and stem, adjustable angle, one percent of full scale accuracy, dual scale, 100 - 550 °C and 200 - 1000 °F, minimum diameter 125 mm (5 inches). Locate at flue gas outlet.
- F. High Steam Pressure Burner Cutouts:

1. Provide two UL listed, FM approved units with different set points. Unit with lowest set point shall be automatic reset; unit with highest set point shall be manual reset.
2. Bellows actuated sealed snap-acting switch or mercury switch with adjustable set point and adjustable differential pressure (automatic reset unit); switch position indicator.
3. Rated for 1375 kPa (200 psi) minimum emergency pressure.
4. Set pressure range: To 150 percent of required set pressure.
5. Provide indicators with graduated scales for set point and differential pressure.
6. Mounting: Connect to water column piping. There shall be no valves between cutoff and boiler shell. Provide siphons at each switch to protect bellows from high temperature.
7. Set Points:
 - a. Automatic Reset Unit: Refer to boiler schedule shown on the drawings. If not shown, set at 35 kPa (5 psi) below the set pressure of the manual reset unit.
 - b. Manual Reset Unit: 35 kPa (5 psi) below lowest safety valve set pressure. Subtractive differential not to exceed 70 kPa (10 psi).
8. Refer to Section 23 09 11, INSTRUMENTATION and CONTROL FOR BOILER PLANT for the operation of the cutouts.

2.3 BURNER AND FUEL TRAINS:

- A. Burner Type: Combination natural gas and fuel oil, packaged, forced draft, modulating firing, variable speed forced draft fan. Design for low NOx emissions.
 1. Gas Burner: Ring type with multiple ports or spuds.
 2. Oil Burner: Gun type, inside mix, low pressure air atomizing.
 3. Igniter (Pilot): Interrupted, electrically ignited, natural gas and propane.
- B. Service:
 1. Continuous operation at all firing rates on each fuel listed under Article, PROJECT CONDITIONS of Part 1. Design the entire burner and fuel train system for application to the specific boiler furnished and for service at the available fuel pressures.
 2. Igniter (Pilot) Fuels: Normal fuel will be natural gas. Propane will be used if there is an interruption in natural gas service.
 3. Main Fuels: After boilers are accepted for operation, choice of fuels will be based on cost and availability.

C. Performance:

1. Igniter (pilot) flame on natural gas and propane shall form close to the point of ignition and shall be stable. Ignite both the gas and oil burner with single igniter.
2. Main flame on gas and oil fuels shall ignite at lowest firing rate.
3. Main flame characteristics at all firing rates:
 - a. Flame retained at the burner.
 - b. Flame stable with no blowoff from the burner or flashback into the burner. No pulsations.
 - c. No deposits of unburned fuel or carbon at any location.
 - d. No carryover of flame beyond the end of the first pass (furnace tube).
4. Operation:
 - a. Minimum turndown: Natural Gas: 10/1; #2 Fuel Oil: 8/1.
 - b. Operate at all loads on any one fuel without any manual changes to burners, fuel trains or fuel pressures, atomizing media trains or pressures.
 - c. Excess Air in Flue Gases with Oxygen Trim at Null Position:

Boiler Steam Output, Percent of Maximum Required Capacity	Percent Excess Air Allowable Range
Below 25	15 minimum
25 - 39	15 - 35
40 - 100	15 - 25

- d. Performance at any load point shall be repeatable after increasing or decreasing the firing rate. Repeatability plus or minus five percent excess air, at 25 percent and higher boiler loading except excess air must remain within ranges specified above.
- e. Oxygen trim control set at maximum position shall not blow out the fire at any load point. At minimum position, the combustion shall not go below stoichiometric.
- f. Noise and Vibration: Refer to Section 23 05 51, NOISE and VIBRATION CONTROL FOR BOILER PLANT for requirements on forced draft fan and oil atomization system. Burners shall operate without pulsation.

5. Flue Gas Emissions Limits:

- a. Carbon Monoxide: Shall not exceed 200 PPM.
- b. Smoke: On natural gas and No. 2 oil shall not be visible and shall not exceed No. 1 on the Bacharach smoke scale.
- c. When burning natural gas: NOx <0.05 lb/MMBTU input.
- d. When burning #2 fuel oil: NOx <0.09 lb/MMBTU input.

D. Construction:

- 1. Burner Access (Main Burner and Igniter): Arrange fuel valve and piping trains, controls and other devices so that they do not interfere with the removal and replacement of burner parts.
- 2. Arrangement of Fuel Valve and Piping Trains: All devices shall be accessible for maintenance or replacement without removal of other devices. Do not attach any piping or devices to boiler casings.
- 3. Coatings: Provide surface preparation, heat resistant prime and finish coats using standard color of boiler manufacturer. Refer to Section 09 91 00, PAINTING.
- 4. Combustion Air System and Flue Gas Recirculation (FGR) System (if provided):
 - a. Air flow rates controlled by forced draft fan inlet or outlet dampers and variable speed drive.
 - b. Symmetrical, balanced distribution of combustion air into the burner.
 - c. Provide induced type flue gas recirculation (FGR) system if FGR is necessary to achieve specified NOx limits. All FGR ductwork shall comply with Section 23 51 00, BREECHINGS, CHIMNEYS, and STACKS.
 - d. Forced Draft Fan: Airfoil or backwardly inclined wheel, electric motor driven. Design for required excess air and for static pressure that is based on losses from fan inlet to stack or chimney outlet, including economizer (if provided), at jobsite altitude. Fan shall have no resonant frequencies at all operating speeds.
 - i. Provide speed and direction pickups on fan shaft and indicate speed/direction status to control system.
 - e. Motor: TEFC or open drip proof, non-overloading under all fan operating conditions, design for 40 °C ambient, premium efficiency type. Motors for variable speed service shall be rated inverter-

ready. Refer to Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT and STEAM GENERATION.

- i. Provide split CT's on each motor lead to detect loss of current on each leg, tied into the flame shutdown system to shut down boiler.
- f. Damper: Design to provide accurate control of excess air with minimum hysteresis. On variable speed systems, the damper shall control only at lower firing rates.
- g. Motor Starter Panel: Provide motor starter and variable speed drive mounted in NEMA 4 enclosure, readily accessible. Refer to Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT and STEAM GENERATION. Refer to Section 23 09 11, INSTRUMENTATION and CONTROL FOR BOILER PLANT, for burner management system motor power interlocks.
- h. Sound Attenuators: Provide attenuators on forced draft air intakes to reduce sound levels to allowable limits. Refer to Section 23 05 51, NOISE and VIBRATION CONTROL FOR BOILER PLANT.
5. Provide viewport, with one clear and one tinted replaceable interchangeable glass. Locate to permit view of main and igniter flames.
6. Burner Throat: Refractory tile, shaped to promote proper combustion, arranged with provisions for expansion and contraction and rated by the refractory manufacturer for the maximum service conditions.
7. Electrical Conduit: Provide liquid-tight flexible metal conduit with sealing fittings for all power and control services to fuel trains and burners. Refer to Section 26 05 33, RACEWAY and BOXES FOR ELECTRICAL SYSTEMS.
8. Factory Testing: Mount burner and controls on boiler at factory and fire-test at all load points.
- E. Natural Gas Main Fuel Train:
 1. Arrangement: Comply with requirements of VA Boiler Plant Safety Device Testing Manual, Third Edition (2008), and typical arrangement in NFPA 85, Annex A, as modified by the following description: Starting at the entrance to the train, the devices are, in sequence: plug valve, filter, pressure gage, pressure regulator, valved connection to pilot burner fuel train, flow meter (if required), pressure gage, low pressure switch, two automatic safety shut off valves, valved leak test, high pressure switch, fuel flow control

- valve, plug valve, pressure gage, burner. Provide tee connection for vent between the automatic safety shut off valves. Vent line shall include valved leak test connection, automatic vent valve, valved leak test connection, lockable plug valve, vent thru roof. High and low pressure switches shall be located to sense the constant pressure controlled by the burner pressure regulator and not the variable burner pressure.
2. Filter: Replaceable fiberglass or cellulose cartridge, 10 micron or smaller particle retention. Static pressure capability two times the maximum lock-up pressure of nearest upstream pressure regulator. Maximum pressure loss at high fire 1.3 kPa (5 inches water column). Provide vent with cock for relieving pressure in filter.
 3. Pressure Regulator:
 - a. Single seated, diaphragm-operated, designed for natural gas service. Controlled pressure shall be sensed downstream of main valve. Valve may be self-operated or pilot-operated as necessary to comply with performance requirements.
 - b. Service: Provide precisely controlled downstream pressure in fuel train, as required by burner and fuel trains furnished, with upstream pressure as shown or specified. Inlet and outlet emergency pressure rating shall be at least twice the lock-up pressure of the nearest upstream pressure regulator.
 - c. Performance: Maximum outlet pressure droop 5 percent of the set pressure over the burner firing range. Maximum lock-up pressure 1.5 times regulated pressure. Speed of response to opening of automatic safety shut off valves shall be sufficient to allow set pressure of low pressure switch to be within 20% of the normal operating pressure with no nuisance burner trips.
 - d. Construction, Main Valve: Cast iron body, replaceable plug and seat. Downstream pressure-sensing line.
 4. Automatic Safety Shut-Off Valves:
 - a. Type: Motorized-opening, spring closing, controlled by burner control system. Two valves required.
 - b. Service: Provide open-shut control of fuel flow to burner. Valves shall shut bubble tight and be suitable for operation with upstream pressure of two times the highest pressure at entrance to boiler-mounted regulators.

- c. Performance: Timed opening of six seconds or less to safely and smoothly ignite main flame, and close within one second.
 - d. Construction: Valves 65 mm (2-1/2 inches) and larger, flanged ends; valves 50 mm (2 inches) and below threaded ends; position indicator showing open and shut, visible from front or side of boiler. Aluminum seating surfaces not permitted. Closed position interlock switch on each valve. Valved leak test fittings before and after each valve.
 - e. Approval: FM approved, UL listed for burner service.
 - f. Proof of Closure Test: Provide non-latching push button controls in the proof of closure circuit to complete the circuit when the valves are open and interrupt the circuit when the valves are closed.
5. Automatic Vent Valve:
- a. Type: Motorized or solenoid closing, spring opening, full port, controlled by burner control system.
 - b. Service: Provide open-shut control of vent line that is connected between the two safety shut-off valves. Valves shall shut bubble-tight and be suitable for operation with upstream pressure of two times the highest pressure at entrance to boiler-mounted regulators. Valve shall be open whenever safety shut-off valves are closed.
 - c. Approval: UL listed for burner service.
6. Vent System Manual Plug Valve for Leak Tests: Located on vent line on outlet side of automatic vent valve. Provide locking device and lock wrench to lock valve to open position. Provide cylinder padlock keyed to VA Engineering key. Provide valved leak test connections between automatic vent valve and plug valve and ahead of the automatic vent valve.
7. Pressure Switches: Refer to the article on burner management system in Section 23 09 11, INSTRUMENTATION CONTROL FOR BOILER PLANT. Switch settings must be within 20% of the controlled pressure. High pressure switches shall have lockable service isolating valves and valved connections for pressurizing the switches and testing the set and trip points.
8. Fuel Flow Control Valve:

- a. Type: Throttling, controlled by combustion control system (Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT).
 - b. Performance and Service: Control fuel flow in exact proportion to combustion airflow over the entire firing range of the burner. Static pressure rating shall exceed the lockup pressure of the boiler-mounted regulator.
 - c. Valve Requirement for Single Point Positioning Jackshaft Control Systems: Valve shall have adjustable characterization cam shaped by at least twelve adjustment screws.
9. Pressure Gages, Flow Meter: Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.
- F. Fuel Oil Train:
1. Arrangement: Comply with VA Boiler Plant Safety Device Testing Manual, Third Edition (2008), typical arrangement in NFPA 85, Annex A, as modified by the following description: Starting at the entrance to the train, the devices are, in order: manual shut off valve, filter, pressure gage, pressure regulator (if required by burner furnished), low pressure switch, high pressure switch, flow meter (if specified), oil flow control valve, thermometer, valved drain, automatic safety shut off valve, valved leak test, automatic safety shut off valve, valved leak test, manual shut off valve, pressure gage, burner.
 2. Filter: Permanent edge-type elements, cleanable by rotation of a handle without interruption of flow. Filter element spacing 0.1 mm (0.0035 inch). Pressure rating shall exceed upstream safety relief valve set pressure plus accumulation. Maximum pressure loss 20 kPa (3 psi) at high fire. Provide plugged drain.
 3. Pressure Regulator: Do not provide unless required by the burner furnished. Pressure control is provided by a back pressure control valve on the house fuel oil pump set.
 4. Automatic Safety Shut-Off Valves:
 - a. Type: Motorized-opening, spring closing, controlled by burner control system. Two valves required.
 - b. Service: Provide open-shut control of fuel flow to burner. Valves shall shut bubble-tight and be suitable for operation with upstream pressure exceeding upstream safety relief valve set pressure plus accumulation.

- c. Performance: Timed opening of six seconds or less to safely and smoothly ignite oil burner, one-second closure.
 - d. Construction: Threaded ends, valve position indicator visible from front or side of boiler. Closed position interlock switch on each valve.
 - e. Approval: FM approved, UL listed for burner service.
 - f. Provide valved leak test connections between the two safety shut-off valves and after the second safety shut-off valve.
 - g. Proof of Closure Test: Provide non-latching push button controls in the proof of closure circuit to complete the circuit when the valves are open and interrupt the circuit when the valves are closed.
5. Pressure Switches: Refer to the article on burner management system in Section 23 09 11, INSTRUMENTATION and CONTROL FOR BOILER PLANT. Switch settings must be within 20% of the controlled pressure. High pressure switches shall have lockable service isolating valves and valved connections for pressurizing the switches and testing the set and trip points.
6. Fuel Flow Control Valve:
- a. Type: Throttling, controlled by combustion control system (Refer to Section 23 09 11, INSTRUMENTATION and CONTROL FOR BOILER PLANT).
 - b. Performance and Service: Control fuel flow in exact proportion to combustion airflow over the entire firing range of the burner. Static pressure rating shall exceed the lockup pressure of the boiler-mounted regulator.
 - c. Valve Requirement for Single Point Positioning Jackshaft Control Systems: Valve shall have adjustable characterization cam shaped by at least twelve adjustment screws.
7. Pressure Gages, Thermometers, Flow Meter: Refer to Section 23 09 11, INSTRUMENTATION and CONTROL FOR BOILER PLANT.
8. Boiler/Burner-Mounted Oil Pump and Relief Valve: Do not provide. House pumps are provided that include relief valves.
- G. Low Pressure Air Atomizing System:
- 1. Complete system for each burner, furnished by burner manufacturer, including compressor and drive, air filter, after cooler, low pressure switch and all piping systems.

2. Motor: Premium efficiency type. Refer to the Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT and STEAM GENERATION.
 3. Motor Controls: Provide motor starter in NEMA 4 enclosure. Refer to Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT and STEAM GENERATION. Refer to Section 23 09 11, INSTRUMENTATION and CONTROL FOR BOILER PLANT, for burner management control interlock providing power supply to motor.
 4. Shaft couplings: All metal, flexible.
 5. Sound Attenuators: Provide compressor enclosure, air intake silencer, or other means to reduce sound levels to those required. Refer to the Section 23 05 51, NOISE AND VIBRATION CONTROL FOR BOILER PLANT.
 6. Pressure Gages and Pressure Switches: Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.
- H. Igniter (Pilot) Fuel Train, Burner and Ignition System:
1. Arrangement: Comply with typical arrangement in NFPA 85, Annex A, as modified by the following description: Arrange the system to allow selection of either natural gas or propane for the ignition fuel. Provide separate piping with plug valve, pressure gage, filter and pressure regulator for natural gas and for propane. Connect to the main burner natural gas service downstream of the main burner pressure regulator. Join the natural gas and propane services by means of a three-way plug valve. Continue with one pipe line including a low pressure switch, pressure gage, automatic safety shut off valve, automatic vent, automatic safety shut off valve, igniter.
 2. Filters: Replaceable elements, five micron or smaller particle retention. Static pressure capability two times the maximum lockup pressure of nearest upstream pressure regulator. Maximum pressure loss, at full flow, 1.3 kPa (5 inches water column). Provide unions for filter removal.
 3. Pressure Regulators:
 - a. Type: Single-seated, diaphragm-operated. Provide separate regulators for natural gas service and for LP gas service
 - b. Service: Provide controlled pressure in igniter train as required by igniter, with upstream pressures as shown or specified. Inlet and outlet emergency pressure rating shall be at least twice the lockup pressure of the nearest upstream pressure regulator. As an

alternate to the outlet emergency pressure rating, provide internal relief valve vented to outside set at pressure that will avoid overpressure on regulator outlet that could damage the regulator.

- c. Performance: Lockup pressure shall not exceed 1.5 times the regulated pressure.
- d. Construction: Propane regulator must be designed for LP gas.
- 4. Automatic Safety Shut-Off and Vent Valves:
 - a. Type: Solenoid-type, two normally closed shut-off valves and one normally-open vent valve, arranged as shown, controlled by the burner control system. Provide threaded leak-test ports with threaded plugs on each shut-off valve body.
 - b. Service: Provide open-shut control of fuel flow to igniter and vent between shut-off valves. Design for 140 kPa (20 psi) differential at shut-off.
 - c. Approval: Safety shut-off valves UL listed, FM approved for burner service. Vent valves UL listed for burner service.
- 5. Vent System Manual Plug Valve for Leak Tests: Located on vent line on outlet side of automatic vent valve. Provide locking device and lock wrench to lock valve to open position. Provide cylinder padlock keyed to VA Engineering key. Provide valved leak test connections between automatic vent valve and plug valve and ahead of the automatic vent valve.
- 6. Igniter and Ignition System: Provide removable igniter, ignition electrodes, ignition transformer, high voltage cable. Provide shield at ignition area so that spark is not visible to flame scanner from any position on its mounting.
- 7. Igniter fuel train pipe and fittings: ASME B31.1 requirements do not apply. Refer to Section 23 21 11, BOILER PLANT PIPING SYSTEMS.
- 8. Pressure Switch and Pressure Gages: Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT

2.4 BURNER MANAGEMENT (FLAME SAFEGUARD) SYSTEM AND ACCESSORIES:

- A. Refer to Section 23 09 11, INSTRUMENTATION and CONTROL FOR BOILER PLANT.
- B. Control Panel: Controls shall be mounted in NEMA 4 enclosure on side of boiler or on burner. There shall be no power wiring in this enclosure.
- C. Factory Testing: Install controls on boiler and burner at factory and test operation of all devices.

2.5 FLUE GAS ECONOMIZER:

- A. Heat exchangers to transfer heat from boiler flue gases to boiler feedwater.
- B. Type: Rectangular configuration, replaceable finned tubes, up flow flue gas, parallel flow water, insulated casing with removable panels allowing access to all tubes for cleaning and replacement. Arrange tubes to permit lane-type soot blowing.
- C. Performance: Refer to schedules on drawings. Coordinate input flue gas temperatures with data from boiler manufacturer.
- D. Construction:
 - 1. Comply with ASME Boiler and Pressure Vessel Code, Section VIII. Design unit to permit operation with no water in the tubes at the temperature listed below.
 - 2. Design Pressure:
 - a. Water Tubes, 2050 kPa (300 psi) minimum.
 - b. Inner Casings, 2.5 kPa (10 inches water column) minimum.
 - 3. Design Temperature, 370 °C (700 °F).
 - 4. Tubes and Headers: ASTM A254, Type 316 Stainless steel. Helically wound non-serrated stainless steel fins continuously welded to tubes. 2050 kPa (300 psi) flanged piping connections. Drainable by gravity. Return bend areas shall be exposed to the bulk temperature of the flue gas. Headers shall be external to the casing. Fin density shall not exceed 157 fins per meter (48 fins per foot). Maximum fin height, 13 mm (0.5 inches).
 - 5. Casing: Double wall, removable panels, with insulation between walls. 80 mm (3 inch) angle flanges on flue gas inlet and outlet for attachment of breeching and stack.
 - a. Inner Casing, stainless steel, all welded. Steel angles for breeching attachment to casing. Entire casing systems must be gas tight.
 - b. Insulation: Mineral fiber, ASTM C612, 50 mm (2 inches) thick.
 - c. Outer Casing: Galvanized or painted steel, 0.4 mm (0.016 inches) thick.
- E. Accessories:
 - 1. Safety Relief Valve: Valve designed for steam and water service, ASME - National Board certified, selected by economizer manufacturer in accordance with ASME Code requirements. Set pressure 1900 kPa (275 psi) gage.

2. Soot Blowers: Steam-operated, rotating valve-in-head. Provide sufficient number of blowers to clean all tube areas. Location, arrangement and quantity based on recommendations of soot blower manufacturer for type and size of economizer furnished. Soot blowing shall be lane-type.

3. Inlet and Outlet Transitions: Designed and furnished by economizer manufacturer.

F. Factory Test and Inspections: Inspect the completed economizer assembly in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII. Certify the inspection and submit four copies of completed ASME Form P-3 for each economizer.

2.6 TOOLS:

- A. Oil Burner Vise and Wrenches: Deliver to Contracting Officer's Technical Representative (COTR) for mounting by VA personnel. Furnish only if burners require vise and wrenches not stocked by local tool suppliers.
- B. Boiler Tube Brushes: Furnish hand brushes of sizes, and with handle lengths, to clean full length of all tubes in boiler. Provide handle and extension sections 1800 mm (6 feet) long or less to permit storage. Coupled lengths shall be suitable for use from front of boiler.

2.7 SPARE PARTS:

- A. Fuel Trains:
1. One of each type and size of main and pilot fuel motorized and solenoid automatic safety shut-off valves and automatic vent valves.
 2. Complete set of filter elements and gaskets for each gas filter for each boiler.
 3. Complete set of all gaskets for each edge-type oil filter for each boiler.
- B. Boiler, Burner, Trim, Feedwater Control System:
1. One assembly of electrodes, transformer, and high voltage lead with end connectors for igniters.
 2. Two complete sets of gaskets, for each boiler, to fit all doors, handholes, manholes.
 3. One clear lens and one tinted lens for each furnace and burner observation port on each boiler.
 4. Sufficient tubular glass inserts and gaskets to re-equip water level gage glasses on each boiler.
 5. One set of drive belts for each belt-driven apparatus for each boiler.

6. One gallon oil for atomizing air compressor.
7. Complete set of air compressor intake filter elements for each compressor, for each boiler, if disposable filters are provided.
8. One complete feedwater control valve and actuator.

2.8 ACCESS PLATFORMS:

- A. Provide access platforms as indicated on drawings for operator access to the following items:
 1. Safety valves.
 2. Economizer.
 3. Feedwater header isolation valves and bypass as indicated.
- B. Access platforms shall include toe kick plates, and railings meeting requirements of state and local building codes.
- C. Catwalks adjoining the boiler-supported access platforms shall be provided by the GC.

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. Refer to Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT and STEAM GENERATION.
- B. Boiler and Burner Access Openings: Arrange all equipment and piping to allow access to openings without disassembly of equipment or piping. Provide space that permits full opening of all boiler and burner doors, panels and other access openings. Provide space for pulling full length of all boiler tubes directly from their installed location.
- C. Drainage Facilities for Boiler Water Column, Gage Glass, Low Water Cutoffs, Water Level Alarms:
 1. Refer to Detail, FIRETUBE BOILER.
 2. Locate and orient sight flow indicators so that one person can view the fluid flow while simultaneously operating drain valves and low water cutoff shunt switches.
- D. Boiler Flue Gas Outlet Location: Drawings show a location based on an assumption on the number of passes of the boilers. If the boilers submitted have a different flue gas outlet location, redesign and relocate the stack and breeching systems, at no additional cost to the Government.
- E. Boiler Casing Flashing: Flash or seal all openings in the casing at the top of the boiler at the piping and the flue penetrations to prevent leakage of water into the boiler insulation.

3.2 CLEANING AND PROTECTION FROM CORROSION:

A. Refer to Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT and STEAM GENERATION.

B. Boiler Cleaning:

1. Upon completion of installation, the initial firing of the burner shall be performed to boil out, under supervision of boiler manufacturer, all internal surfaces with chemical solution recommended by boiler manufacturer, to remove all mill scale, corrosion products and other foreign material. Following boil out, boiler shall be washed and flushed until water leaving the boiler is clear. Drain boiler, inspect internal surfaces for cleanliness, then refill boiler with softened and treated water.
2. Refer to the Article INSPECTIONS AND TESTS for requirements for cleaning boiler after operational tests are completed.

C. Protection from Corrosion:

1. Protect the boilers from fire-side and water-side corrosion at all times.
2. Dry Storage: When the boilers are not filled with water, protect the water-sides and fire-sides with a dry storage method recommended by either the boiler manufacturer or the ASME Code, Section VII.
3. Wet Storage: If, after water is placed in the boilers, they are not fired for equipment adjustment or testing for more than two weeks, the boilers shall be protected with a wet storage method recommended either by the boiler manufacturer or the ASME Code, Section VII.
4. Chemical Treatment: The quality of the water in the boilers shall be maintained by a professional water treatment organization. This organization shall provide on-site supervision to maintain the required water quality during periods of boiler storage, operating, standby and test conditions. Furnish monthly reports by the water treatment organization, to the COTR. The Contractor shall provide all chemicals, labor and professional services until the Government has accepted the boilers for operation. All chemicals utilized must conform to FDA guidelines applicable for steam used in food preparation.

3.3 INSPECTIONS AND TESTS:

A. The following tests and demonstrations must be witnessed by the COTR or his/her representative, and must prove that boilers, economizers, burners, controls, instruments, and accessories comply with requirements. Refer to Section 23 08 11, DEMONSTRATIONS and TESTS FOR

BOILER PLANT for general requirements. When test results are not acceptable, make corrections and repeat tests at no additional cost to the Government. Pretests do not require the presence of the RE.

- B. Condition of Boiler and Economizer After Delivery, Rigging, Placement: After setting boiler on foundation and placing economizer on supports, and prior to making any connections to boiler and economizer, the Contractor and RE shall jointly inspect interior and exterior for damage. Correct all damage by repair or replacement to achieve a like new condition.

C. Hydrostatic Tests:

1. Boiler, Economizer: Contractor shall provide inspector certified by National Board of Boiler and Pressure Vessel Inspectors to conduct tests after equipment is installed and connected for operation and prior to initial firing. Test pressure shall be 1-1/2 times the design pressure of the boiler for a period required by the inspector. Provide written certification of the satisfactory test, signed by the inspector. Correct any deficiencies discovered during the testing, and retest equipment until satisfactory results are achieved and are accepted by the inspector.
2. Boiler External Piping (as defined by ASME B31.1, Power Piping):
 - a. Refer to Section 23 21 11, BOILER PLANT PIPING SYSTEMS.
 - b. Test may be conducted concurrently with boiler and economizer testing.
3. Identify and remove any connecting equipment which is not rated for the test pressure. Cap the openings left by the disconnected equipment. Reinstall the equipment after tests are completed.

D. Boiler Steam Safety Valves:

1. Test each valve set pressure and blowdown pressure with boiler steam pressure. Perform accumulation test by operating burner at high fire to verify that safety valve flow capacity is sufficient to handle the maximum boiler steaming rate. Tests shall be performed with boiler isolated from the main steam header and all generated steam exhausting through the safety valves.
2. Valve Popping Tolerance: Plus or minus three percent of set pressure for set pressures over 480 kPa (70 psi) gage.
3. Valve Blowdown Tolerance: Reset at not less than 6 percent below set pressure of valve with the lowest set pressure. Minimum blowdown two percent of the set pressure.

4. Accumulation Test: With burner at high fire, the boiler pressure shall not rise more than six percent above the set pressure of the safety valve with highest pressure setting and shall remain below the maximum allowable working pressure of the boiler.

E. Burner Control (Flame Safeguard-Burner Management) System:

1. Demonstrate operation of all control, interlock and indicating functions. Refer to Section 23 09 11, INSTRUMENTATION and CONTROL FOR BOILER PLANT.
2. Prior to scheduling final test submit certification that all control, indicating, and interlock functions have been pretested.
3. Conduct final test immediately prior to boiler-burner tests.
4. Experienced personnel representing the manufacturer of the system shall conduct the tests.

F. Performance Testing of Boiler, Burner, Economizer, Combustion Control, Boiler Plant Instrumentation:

1. Perform tests on each boiler on all main burner fuels.
2. If required by local emissions authorities, provide services of testing firm to determine NOx and carbon monoxide. Test firm shall be acceptable to emissions authorities.
3. Test No. P-1:
 - a. Operate boiler on each fuel, with economizer in service and record data for at least ten evenly spaced steam loads from low fire start to 100% of full steam output, and in the same sequence back to low fire. Demonstrate performance and efficiency required by paragraphs under Articles, BOILER, BURNER AND FUEL TRAINS, and ECONOMIZER and by boiler and economizer equipment lists on drawings.
 - b. Demonstrate proper operation of combustion controls, draft control (if provided), feedwater level controls, and instrumentation systems (Refer to Section 23 09 11, INSTRUMENTATION and CONTROL FOR BOILER PLANT.
 - c. When flue gas oxygen trim is provided, conduct tests with trim control on manual at the zero trim (null) position. Refer to Section 23 09 11, INSTRUMENTATION and CONTROL FOR BOILER PLANT. After completion of tests with trim control on manual control, repeat the tests on one fuel with the trim control on automatic control.
4. Test No. P-2:

- a. Demonstrate sound level of fans and burner systems and atomizing air compressor.
 - b. Test point shall be at 100 percent of maximum boiler load.
 - c. Refer to sound level requirements in Section 23 05 51, NOISE and VIBRATION CONTROL FOR BOILER PLANT.
5. Test No. P-3:
 - a. Check current draw of forced draft fan motor at prepurge and at 100 percent of maximum boiler load.
 - b. Current draw shall not exceed full load current stamped on motor nameplate.
 - c. This test may be combined with Test No. P-1.
6. Test Methods:
 - a. Utilize permanent instrumentation systems for data. All systems shall be operable and in calibration.
 - b. Utilize portable thermocouple pyrometer furnished and retained by Contractor to measure stack temperature as a verification of permanent stack temperature recorder.
 - c. Use portable electronic flue gas analyzer to determine constituents of flue gas. Analyzer shall be capable of measuring oxygen in per cent with accuracy of plus or minus 0.5 percent oxygen and carbon monoxide in parts per million (ppm) with accuracy of plus or minus 5 percent of reading (Range 0-1000 ppm). Obtain oxygen and carbon monoxide readings at each test point. Calibrate instrument with certified test gases within three months prior to use and immediately after analyzer cell replacement.
 - d. In Test No. P-1 retain boiler at each load point for a time period sufficient to permit stabilization of flue gas temperature and other parameters.
 - e. Steam loads for tests may be furnished by the hospital systems, by operation of the steam silencer vent system, or by a combination of the above. If variable hospital loads interfere with testing, conduct tests at night or on weekends when loads are more stable.
 - f. Utilize dry bulb and wet bulb thermometers furnished and retained by Contractor for checking combustion air.
 - g. Smoke testing shall be by visual observation of the stack and by smoke density monitor (permanent instrument - if provided). If

smoke density monitor is not provided, utilize Bacharach Model 21-7006 Smoke Test Kit. If there is disagreement with the results of these tests, provide qualified observation person and tests in compliance with EPA Reference Method 9 (CFR 40, Part 60, Appendix A).

- h. Sound level instruments will be Government furnished.
 - i. NOx emissions shall be tested with electronic analyzer reading in parts per million. Analyzer shall be calibrated with certified test gas within three months prior to use. Analyzer shall be accurate to plus or minus 5% of reading.
 - j. An additional efficiency test will be required, conforming to ASME Performance Test Code PTC 4, if the boiler efficiency determined in the Test P-1 above, does not comply with requirements. Utilize ASME Test Forms PTC 4.1.a, 4.1.b, and the abbreviated input-output and heat balance methods.
7. Pretesting:
- a. Perform pretest at the final stage of the burner fine-tuning process.
 - b. Prior to scheduling final test, submit evidence of pretest. Evidence shall consist of start-up data sheets signed and dated by personnel representing burner manufacturer, combustion controls manufacturer, burner controls manufacturer.
 - c. Pretest data sheets shall list the following data for each fuel and at each fuel valve controller position, starting at minimum position, proceeding to the maximum position and returning to the minimum position.
 - 1) Fuel flow and air flow controller position.
 - 2) Fuel pressures: At burner and also upstream of fuel flow control valve.
 - 3) Fuel flow rate.
 - 4) Boiler feed pressure, upstream of feedwater regulator (at minimum, 50 percent, maximum firing positions only).
 - 5) Boiler feed temperature (at minimum, 50 percent, maximum firing positions only).
 - 6) Stack temperature: Boiler outlet, economizer (if provided) outlet.
 - 7) Flue gas oxygen and carbon monoxide (utilize flue gas analyzer which has been calibrated with certified test gases).

- 8) Steam flow rate (at minimum, 50 percent, maximum firing position only).
 - 9) Steam pressure - Boiler, Header (at minimum, 50 percent, maximum positions only).
 - 10) Opacity of flue gas.
 - 11) Flue gas NOx (if limit specified).
 - 12) Combustion air temperature - dry bulb and wet bulb.
 - 13) Barometric pressure (one reading).
- d. Calibrate all pressure gages prior to pretest.
- G. Internal Inspection of Pressure Parts and Furnace:
1. After all operational tests are satisfactorily completed, a Government retained, licensed boiler inspector will determine if the boiler is free from corrosion, deposits, and any other type of damage or defect.
 2. In preparation for the inspection, open all manways, handholes, and access doors or panels at the ends of the boiler. Drain and clean the interior of all pressure parts and clean all soot and debris from furnace and fire tubes.
 3. Any corrosion, damage or defect shall be corrected to a like new condition in the judgment of the boiler inspector.
 4. After the boiler inspector has approved the boiler, all manways, handholes, and the access doors shall be closed with new gaskets.
- H. If burner operation results in deposits of carbonaceous materials in the furnace or tubes clean the furnace and tubes, modify the burners as necessary, and retest the burner performance.

3.4 STARTUP AND TESTING

- A. The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the COTR and Commissioning Agent. Provide a minimum of 7 days prior notice.

3.5 COMMISSIONING

- A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS for all inspection, start up, and contractor testing required above and required by the System Readiness Checklist provided by the Commissioning Agent.
- B. Components provided under this section of the specification will be tested as part of a larger system. Refer to Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS and related sections for contractor responsibilities for system commissioning.

3.6 DEMONSTRATION AND TRAINING

- A. Provide services of manufacturer's technical representative for four hours to instruct each VA personnel responsible in the operation and maintenance of units.
- B. Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00 - COMMISSIONING OF HVAC SYSTEMS.

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