SECTION 23 52 33
WATER TUBE BOILERS

SPEC WRITER NOTES:
1. Delete between // // if not applicable to project. Also delete any other item or paragraph not applicable in the Section and renumber the paragraphs.
2. References to pressure in this section are gauge pressure unless otherwise noted.
3. Two types of high pressure water tube boilers are specified, flex tube and D-type. The two boiler types are significantly different, and only one of the two types should typically be specified if all new boilers in a given project are similar.
4. Flex tube boilers:
   a) Primarily for non-critical service firing gas fuel and with stable steam demands. Expected life is 15 to 20 years. The designer must obtain VHA OCAMES and VA CFM CSS approvals at the beginning of design phase for the use of this type of boiler, because of the reduced life expectancy.
   b) In addition to natural gas, only No.2 fuel oil should be fired and in limited quantity because of the difficulty of cleaning soot from the tubes.
   c) Because of the relatively small diameter of the steam drum, steam quality may be unsatisfactory and carryover may occur if there are rapid and substantial fluctuations in steam demands. Three-element water level control is advisable.
   d) Mechanical cleaning of the tube interiors is not possible. Chemical cleaning is necessary.
   e) Acceptable manufacturers are BMW, Bryan, Cleaver Brooks, English, and Unilux. Maximum boiler horsepower of Bryan and Cleaver Brooks boilers is approximately 5.9 MW (600 hp). BMW, English, and Unilux have larger boilers.
5. D-type two pass water tube boilers:
   a) D-type boilers are recommended for critical industrial and institutional service where longevity and reliability are

essential. Expected life is 40 years.
b) Various fuels, including heavy oil, can be burned satisfactorily.
c) Applications are typically for steam loads approximately 25,000 lb/hr and greater. This type is available for lower loads, but it is much more expensive and less efficient than the fire tube type which should be utilized for the lower steam demands.
d) The pressure vessel interior and furnace are relatively easy to inspect. Tubes can be cleaned mechanically.

6. Contract drawings must include (as applicable) the VA National CAD Standards listed below:
SD235233-01 Water Tube Boiler
SD235233-02 Access Platform Arrangement for Water Tube Boiler
SD232111-07 Boiler Feedwater Pumps Flow Diagram
SD232111-08 Boiler Flow Diagram

PART 1 - GENERAL

1.1 DESCRIPTION

A. This section specifies packaged water tube boiler with trim (accessories), dual fuel (natural gas and fuel oil) burner, fuel trains//, and flue gas economizer//.

B. A complete listing of common acronyms and abbreviations are included in Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION.

1.2 RELATED WORK

A. Section 01 00 00, GENERAL REQUIREMENTS.

B. Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

C. Section 01 81 13, SUSTAINABLE CONSTRUCTION REQUIREMENTS.

D. //Section 01 91 00, GENERAL COMMISSIONING REQUIREMENTS.//

E. //Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.//

F. Section 23 05 10, COMMON WORK RESULTS FOR BOILER PLANT AND STEAM GENERATION.

G. Section 23 05 51, NOISE AND VIBRATION CONTROL FOR BOILER PLANT.

H. //Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.//

I. //Section 23 08 11, DEMONSTRATIONS AND TESTS FOR BOILER PLANT.//

J. Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.

K. Section 23 21 11, BOILER PLANT PIPING SYSTEMS.

L. Section 23 50 11, BOILER PLANT MECHANICAL EQUIPMENT.

M. Section 23 51 00, BREECHINGS, CHIMNEYS, AND STACKS.

N. Section 26 05 33, RACEWAY and BOXES for ELECTRICAL SYSTEMS.

1.3 APPLICABLE PUBLICATIONS

SPEC WRITER NOTE: Make material requirements agree with requirements specified in the referenced Applicable Publications. Verify and update the publication list to that which applies to the project, unless the reference applies to all mechanical systems. Publications that apply to all mechanical systems may not be specifically referenced in the body of the specification, but, shall form a part of this specification.

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only. Where conflicts occur these specifications and the VHA standard will govern.

B. American Society of Mechanical Engineers (ASME):

B31.1-2014.....Power Piping

ASME Boiler and Pressure Vessel Code:

BPVC Section I-2015.....Rules for Construction of Power Boilers

BPVC Section VII-2015...Recommended Guidelines for Care of Power Boilers

BPVC Section VIII-2015..Rules for Construction of Pressure Vessels

BPVC Section IX-2015....Welding, Brazing, and Fusing Qualifications

Performance Test Code (PTC):

PTC 4-2013.....Fired Steam Generators

C. ASTM International (ASTM):

A178/178M-2002 (R2012)..Standard Specification for Electric-Resistance-Welded Carbon Steel and Carbon-Manganese Steel Boiler and Superheater Tubes

A269/A269M-2015a.....Standard Specification for Seamless and Welded Austenitic Stainless-Steel Tubing for General Service

C612-2014.....Standard Specification for Mineral Fiber Block and Board Thermal Insulation

D396-2015c.....Standard Specification for Fuel Oils

D. Environmental Protection Agency (EPA):
CFR 40, PART 60, Appendix A,
Method 9-2017.....Visual Determination of the Opacity of Emissions from Stationary Sources

E. Fluid Controls Institute (FCI):
70-2-2013.....Control Valve Seat Leakage

F. Department of Health and Human Services, Food and Drug Administration (FDA):
CFR 21, 173.310-2016....Boiler Water Additives

G. National Board of Boiler and Pressure Vessel Inspectors (NBBI):
NB 23-2015.....National Board Inspection Code (NBIC)

H. National Fire Protection Association (NFPA):
70-2014.....National Electric Code
85-2015.....Boiler and Combustion Systems Hazards Code

I. Department of Veterans Affairs (VA):
.....VHA Boiler Plant Safety Devices Testing Manual, Third Edition

1.4 SUBMITTALS

A. Submittals, including number of required copies, shall be submitted in accordance with Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES.

B. Information and material submitted under this section shall be marked “SUBMITTED UNDER SECTION 23 52 33, WATER TUBE BOILERS”, with applicable paragraph identification.

C. Manufacturer's Literature and Data including: Full item description and optional features and accessories. Include dimensions, weights, materials, applications, standard compliance, model numbers, size, and capacity.

D. Boiler:
1. Complete catalog information and outline drawing of boiler and accessories with dimensions.
2. Arrangement and description of construction of pressure parts, casings, drum internals, drum handhole covers and yokes, and support frame.
3. Drum piping connection sizes, locations, construction.
4. Technical data including temperature ratings and arrangement of refractory and insulation.

5. Steam nozzle construction, including the maximum forces and moments that are allowed to be imposed by connected piping.
6. Amount of heating surface, combustion volume.
7. Weight of boiler and burner assembly, empty and flooded, including corner weights and center of gravity dimensions for coordination with foundation design.
8. Design pressures and temperatures.
9. Recommended anchorage of boiler support frame to foundation.
10. Furnace viewport construction, locations.
11. Dimensioned location of normal water line, lowest and highest permissible water level, set points of water level alarms and cutoffs.
12. Predicted surface temperature at front, rear and sides of boiler.

SPEC WRITER NOTE: Delete the following paragraph if not required.

13. //Seismic design data on boiler and anchorage of boiler to foundation. Refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.//

E. Boiler Trim: Includes bottom blowoff valves, water column with conductivity probe assembly, water level gauge with illuminator, auxiliary low water cutoff, piping, all valves and fittings furnished by boiler manufacturer, feedwater control valve, safety valves, steam pressure gauge, 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 control valve.
6. Scale ranges of gauges, thermometers, and pressure switches.
7. Location of water level sensing and indicating devices in relation to normal water line of boiler and highest and lowest permissible water lines of boiler.
8. Set pressure and capacity of safety valves.

F. Burner and Fuel Trains:
1. Catalog data and drawings showing construction of burner parts and assembly of complete system.
2. Drawings, with dimensions, showing burner overall size and mounting on the boiler.

3. Catalog data and outline drawings of forced draft fan, flue gas recirculation ductwork (if provided), dampers, motors and sound attenuators on fan intake or discharge.
4. Drawings showing assembly of throat refractory into furnace refractory wall.
5. Type and temperature rating of throat refractory.
6. Drawings and catalog data on all equipment in igniter (pilot) train, main fuel trains, atomizing media train. Include data on pressure and temperature ratings, flow vs. pressure drop, performance characteristics, and inspection agency approvals. Complete data on oil atomization air compressor systems with sound attenuators.
7. ASTM number 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 media pressures and flows at maximum required firing rate.
   b. Igniter (pilot) fuel flow and burner pressure.
   c. Natural gas main fuel pressure at outlet of burner-mounted pressure regulator.
   d. Igniter fuel pressures (natural gas and LP gas) at outlet of burner-mounted pressure regulators.
   e. Forced draft fan static pressure, power and air flow at maximum firing rate. Amount of flue gas recirculation.
10. Full load efficiency and power factor of all motors.
11. Predicted sound level at maximum firing rate.
12. Weight of burner assembly.
13. Drawings showing location and arrangement of drive units and jackshaft system (if provided) for controlling fuel and air flow.
14. Weight of burner assembly.
15. Steps required to change from one fuel source to another.

G. Burner Management (Flame Safeguard) Control System: Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.

SPEC WRITER NOTE: Retain the following paragraphs only if flue gas economizer is required.

H. //Flue Gas Economizer:
   1. Drawings showing arrangement and dimensions of unit and all accessories.

2. Design and construction of unit and accessories including safety relief valve.
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. Drawing showing tube arrangement, clearance for tube removal (rectangular units).
7. Manufacturers operating recommendations for mounting and support requirements for economizer (weight-flooded).//

SPEC WRITER NOTE: Delete the following paragraph if not applicable.

I. //Seismic data. Refer to Section 13 05 41, SEISMIC RESTRAINT REQUIREMENTS FOR NON-STRUCTURAL COMPONENTS.//

J. Boiler and Burner Predicted Performance Data, for Each Fuel, Site Altitude:

SPEC WRITER NOTE: Retain references to windbox below only for D-type boilers, because flexible tube boilers do not have a windbox.

1. At Maximum Required Output with and without Economizer (If Applicable) In Service, at 15 Percent Excess Air: 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 (if provided).
2. At Low Fire, 25 percent, 50 percent and 75 percent of Maximum Firing Rate: Percent excess air, carbon monoxide (CO) ppm and NOx ppm.
3. Schematic wiring diagram of boiler control system showing all components, interlocks, etc. Schematic wiring diagram shall clearly identify factory wiring and field wiring and clearly identify the flame safeguard circuits and burner control circuits.
4. The boiler and burner combination used for this project shall be factory tested by the boiler manufacturer at all load points as required by Part 3.

K. ASME “P” Forms, Manufacturer’s Data Report, on boiler and economizer construction.

L. Pretest Data: Boiler, Burner, Controls: As required by Part 3.

M. Final Test Report: Boiler, Burner, Controls: As required by Part 3.

N. Complete operating and maintenance manuals including wiring diagrams, technical data sheets, information for ordering replacement parts, and troubleshooting guide:
   1. Include complete list indicating all components of the systems.
   2. Include complete diagrams of the internal wiring for each item of equipment.
   3. Diagrams shall have their terminals identified to facilitate installation, operation and maintenance.

O. //Completed System Readiness Checklist 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.//

P. //Submit training plans and instructor qualifications in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.//

1.5 QUALITY ASSURANCE

A. Coordinate all new and existing equipment and conditions. This includes, but is not limited to: boiler, boiler trim, burner, fuel trains, gas pressure regulators and available gas pressure, fuel oil header back pressure regulator on house oil pump set and available fuel oil pressure, burner control system, combustion control system, economizer (if provided), breeching and stacks.

B. The model and size of the proposed burner shall have been previously applied to at least three boilers that are similar in size, proportion, and arrangement to the proposed boiler. In each of the three installations, burner performance shall have conformed to requirements listed in Part 2, BURNER and FUEL TRAINS. Provide list of these installations, and name, address and telephone number of person familiar with each project who will serve as a reference source.

SPEC WRITER NOTE: Retain the next paragraph for all boiler sizes even though NFPA 85 states that it only applies to boilers of sizes exceeding 3.6 MW (12,500,000 Btu/h).

C. 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.

1.6 AS-BUILT DOCUMENTATION

SPEC WRITER NOTE: Coordinate O&M Manual requirements with Section 01 00 00, GENERAL REQUIREMENTS. O&M manuals shall be submitted for content review as part of the close-out documents.

A. Submit manufacturer’s literature and data updated to include submittal review comments and any equipment substitutions.

B. Submit operation and maintenance data updated to include submittal review comments, VA approved substitutions and construction revisions shall be //in electronic version on CD or DVD// inserted into a three-ring binder. All aspects of system operation and maintenance procedures, including applicable piping isometrics, wiring diagrams of all circuits, a written description of system design, control logic, and sequence of operation shall be included in the operation and maintenance manual. The operations and maintenance manual shall include troubleshooting techniques and procedures for emergency situations. Notes on all special systems or devices shall be included. A List of recommended spare parts (manufacturer, model number, and quantity) shall be furnished. Information explaining any special knowledge or tools the owner will be required to employ shall be inserted into the As-Built documentation.

SPEC WRITER NOTE: Select and edit one of the bracketed options after the paragraph below to indicate the format in which the contractor must provide record drawing files. Select the hand-marked option only when the designer has been separately contracted to provide the record drawings from the contractor’s mark-ups. Select the BIM option only when a BIM model will be generated, which is typically only performed by the designer on some Design-Bid-Build projects or by the contractor on some Design-Build projects.

C. The installing contractor shall maintain as-built drawings of each completed phase for verification; and, shall provide the complete set at the time of final systems certification testing. Should the installing contractor engage the testing company to provide as-built or any portion thereof, it shall not be deemed a conflict of interest or breach of the ‘third party testing company’ requirement. Provide record drawings as follows:

1. //Red-lined, hand-marked drawings are to be provided, with one paper copy and a scanned PDF version of the hand-marked drawings provided on CD or DVD.//
2. //As-built drawings are to be provided, with a copy of them on AutoCAD version // // provided on CD or DVD. The CAD drawings shall use multiple line layers with a separate individual layer for each system.//
3. //As-built drawings are to be provided, with a copy of them in three-dimensional Building Information Modeling (BIM) software version // // provided on CD or DVD.//

D. The as-built drawings shall indicate the location and type of all lockout/tagout points for all energy sources for all equipment and pumps to include breaker location and numbers, valve tag numbers, etc. Coordinate lockout/tagout procedures and practices with local VA requirements.

E. Certification documentation shall be provided to COR 21 working days prior to submitting the request for final inspection. The documentation shall include all test results, the names of individuals performing work for the testing agency on this project, detailed procedures followed for all tests, and provide documentation/certification that all results of tests were within limits specified. Test results shall contain written sequence of test procedure with written test results annotated at each step along with the expected outcome or setpoint. The results shall include all readings, including but not limited to data on device (make, model and performance characteristics), normal pressures, switch ranges, trip points, amp readings, and calibration data to include equipment serial numbers or individual identifications, etc.

1.7 PROJECT CONDITIONS

SPEC WRITER NOTE: Because of the rarity and complexity associated with the use of heavy fuel oils in VA facilities, this specification has omitted references to No.5 and No.6 fuel oils and to the associated soot blowers. Similarly, biomass fuels are not addressed by this specification. Specifications associated with these systems must be thoroughly investigated and added if required on individual projects.

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 // // MJ/cubic meter (// // Btu/cubic foot) at gas company base pressure and temperature. Pressure provided to the inlet of the boiler-mounted regulators will be // // kPa (// // psig) as maintained by the main gas regulator station.

D. Fuel Oil: Will be furnished under Government contract. House pumping system is designed to provide // // kPa (// // psig) nominal to the fuel train entrance on each burner fuel train. Pressure will vary in accordance with characteristics of backpressure regulator on house oil pump set. Refer to Section 23 50 11, BOILER PLANT MECHANICAL EQUIPMENT. Oil grade (No. 2) refers to ASTM D396.

E. Low Pressure Air Atomizing Burners: Each burner must include a dedicated air compressor system furnished by burner manufacturer.

SPEC WRITER NOTES:
1. Retain one of the next two paragraphs if fuel oil/atomizing is necessary for the project. Steam atomizing is only available on D-type boilers.
2. Note that the requirements here for a dedicated air compressor for each burner are intended to prevent the failure of an atomizing air compressor from becoming a single point of failure that defeats the intent of N+1 redundancy requirements.

F. Oil Atomizing Media:

1. //Steam Atomizing Burners: Steam pressure range at inlet to atomizing train // // to // // kPa (// // to // // psig). When plant is cold (steam not available), compressed air (0.8 standard cubic meters per minute at 550 kPa) (30 SCFM at 80 psig) is available (from plant compressor) as an alternate for starting any boiler and continuously operating it at a required steam output of 13 percent of full load.//
2. //Low Pressure Air Atomizing Burners: Each burner must include a dedicated air compressor system furnished by burner manufacturer.//

G. LP Gas (Propane): Furnished to the Government for igniter (pilot) fuel by a local supplier. Regulators at tank areas will be set at 34 kPa (5 psig). Serves as igniter fuel when there is an interruption to the natural gas supply.

PART 2 - PRODUCTS

SPEC WRITER NOTE: Choose D-type (paragraph 2.1) or flexible tube boiler (paragraph 2.2). Refer to the Spec Writer Notes at the beginning of the section for comparisons between the types of boilers.

2.1 D-TYPE WATER TUBE BOILER

A. Factory-assembled, packaged water tube, industrial-class, high pressure steam boiler. Two drum, "D-type" furnace tube configuration, two pass. Designed for natural gas and fuel oil firing.

B. Service: Designed to continuously receive feedwater at 100 degrees C (212 degrees F) and generate steam at pressures and quantities shown.

C. Performance:

1. Steam output quantity, refer to drawings.
2. Steam output quality, 99 percent minimum at all steam flow rates. Based on water quality in boiler of 3500-ppm maximum total solids, 15-ppm maximum suspended solids, 700-ppm maximum alkalinity.
3. Minimum Efficiency at Required Maximum Output:
   a. Natural Gas Fuel (37.3 MJ/cubic meter) (1000 Btu/cubic foot): 78 percent at 15 percent excess air or 80 percent at 5 percent excess air.
   b. Fuel Oil (ASTM D396 Grade 2, 4, 5, or 6): 83 percent at 15 percent excess air or 81.5 percent at 5 percent excess air.

D. Boiler Heating Surface and Furnace Volume:

SPEC WRITER NOTE: Verify that heating surface area is listed on the contract drawings.

1. Heating Surface Area: Provide surface area necessary to obtain required performance, however surface area shall not be less than shown on the drawings. Heating surface is defined as flat projected tube surface, including fins, in combustion space, whether or not covered by refractory, plus outside (gas side) circumferential area of all convection tubes.

SPEC WRITER NOTE: Combustion volume requirements are conservative to reduce the potential for flame impingement.

2. Furnace (Combustion) Volume: Heat release at full load shall not exceed 517,000 watts per cubic meter (50,000 Btu/h per cubic foot). Combustion volume limits shall not extend beyond first plane of entry into convection tubes. Screen tubes, when used, shall be

considered the first plane of entry. Steady constant direct contact or impingement of the flame on any surface is prohibited.

E. Minimum Design Pressure: Shall equal the ASME-stamped maximum allowable working pressure of 1380 kPa (200 psig). Purpose of high design pressure is to provide additional corrosion allowance and additional safety margin to perform safety device testing.

F. Construction:

1. Codes: Comply with ASME Boiler and Pressure Vessel Code, Sections I, II, VII, and IX.
2. //Design shall accommodate thermal expansion and seismic shocks (in seismic areas).//
3. No element of the boiler or accessories shall be overstressed, displaced, or 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.
4. Base Frame: Design for mounting on flat concrete base. All elements shall be level and square. Provide attachments for anchorage to concrete foundation.
5. Provide lifting lugs and jacking pads.
6. Drums:
   a. Steam drum shall be minimum 900 mm (36 inch) diameter. Bottom drum shall be minimum 600 mm (24 inch) diameter. Equip steam drum with elliptical side-hinged manway on each end. Equip bottom drum with non-hinged elliptical manways at each end. Equip all manways with properly fitted forged steel yokes, bolts, nuts, and non-asbestos gaskets. Manway covers shall have bolt slots forged integral with covers. Provide access to all manways clear of piping, valves.
   b. All tube holes shall be grooved and sized for 50 mm (2 inch) tubes and shall be radial and properly located to permit proper alignment of tubes. Swaged tubes with reduced drum openings are prohibited.
   c. Intermediate header for water wall or convection tubes are prohibited.
7. Drum Piping Connections:
   a. Flanged, except threaded are permitted for pipe size less than 65 mm (2-1/2 inches).

SPEC WRITER NOTE: Steam nozzle forces and moments imposed by connecting piping must be scheduled on the drawings.

b. Steam nozzle shall be 2070 kPa (300 psig) ANSI flanged. Design nozzle and drum assembly to withstand forces and moments imposed by connected piping. Studding nozzle is prohibited.
c. Locate boiler manual steam vent to permit access to gate valve from platform located above boiler.
d. Locate safety valve outlets to permit straight run of vents through roof and to permit valve handle access from platform located above boiler.
e. Separate connections for water column and auxiliary low water cutoff.
f. Connections for boiler feedwater, chemical admission, combined continuous blow down and water sampling. Locate as shown on the drawings.
g. Bottom drum blowoff.
h. Water level sensor connections (for incoming feedwater control).
i. Pressure gauge and pressure switch connections.
j. Two 50 mm (2 inch) piping connections on rear head of bottom drum for steam heater for keeping boiler warm in standby mode. Also, connection for temperature sensor for temperature control valve.

8. Drum Internals:
   a. Steam purification equipment, including dry pan separators, plate-type baffles and other devices as necessary, to meet steam quality requirements and provide proper water levels in the boiler steam drum.
   b. Boiler feedwater admission system to properly distribute feedwater.
   c. Chemical feed piping to permit infusion of mixture of water treatment compounds along entire length of drum by continuous feed system.
   d. Continuous blowdown and water sampling system as combined unit designed to collect water along entire length of drum.
   e. Bottom drum blowoff system to properly collect sediment from bottom drum and to permit complete collection of sediment and drainage.

f. Steam heating pipes in bottom drum to keep boiler warm on standby. Cap for future connections of steam supply and condensate return.

g. Drum internal fittings shall be provided, securely mounted and easily removable for boiler internal access for inspections and cleaning.

9. Tubes:

a. ASTM A178/178M Grade A, seamless or electric resistance welded, outside diameter 50 mm (2 inch) or greater. Uniform internal area, not swaged at drum connections, bend radii permitting turbine cleaning by mechanical tube cleaner.

b. Arrange convection tubes in alternate narrow and wide rows to permit tube removal without removing adjacent tubes.

c. Front furnace tubes (if provided) shall be completely clear of burner throat and bullring and arranged to permit maintenance of front wall refractory system without tube removal.

d. Provide rear water wall tubes covering a minimum of 80 percent of the rear wall area. Arrange tubes to permit unobstructed view through observation ports in the rear wall and to permit maintenance of rear wall refractory without removing tubes.

e. Tubes separating the furnace from the convection area shall have continuous fins welded to each side of the tubes and to each other to form a pressure-tight membrane wall to prevent flue gas bypass of the furnace and convection spaces.

10. Refractory:

a. Refractory quality and temperature characteristics shall be suitable for long-term service at the maximum operating conditions and shall be the boiler manufacturer’s experience-proven selection. Incorporate refractory systems in the front and rear walls, and seal interface between combustion and convection areas. Repair and replacement of refractory shall be possible without alteration to pressure parts of boiler.

SPEC WRITER NOTE: Castable refractory walls are prohibited because of experiences with cracking in this type of wall.

b. Front and Rear Walls: Construct of shiplap firebrick arranged to permit expansion and contraction. Do not use castable refractory except to seal locations where bricks cannot be used. Provide

bullring constructed of firebrick to protect burner throat refractory from forces generated within front wall. Provide expansion joint between bullring and burner throat. Incorporate openings in rear wall for observation ports, and for access to furnace as specified under paragraph, CASING, SETTING AND INSULATION. Access opening shall include a removable refractory plug.

11. Casing, Setting and Insulation:
    a. Provide double wall casing system with insulation between the walls. Inner casing can be a welded finned-tube inner wall. The inner casing or welded fin tube construction shall be sealed to prevent the combustion gases from coming in contact with the outer casing.
    b. Design casing at the combustion gas outlet to receive approved stack or breeching transition section as shown. Refer to plans for details of gas outlet arrangement.
    c. Provide furnace access door located near the furnace floor. Use of burner throat as access is prohibited. Equip furnace access door opening with refractory, backed up by insulation and airtight cover system.
    d. Provide three 50 mm (2 inch) diameter observation ports in rear wall of furnace located to permit observation of each sidewall of furnace and full area of burner throat and bullring. Furnish each port with clear and tinted interchangeable glass; gas tight sliding metal closure between glass and furnace, forced air-cooling.
    e. Provide convection space inspection openings sealed with caps removable for inspection.
    f. Insulation shall be manufacturer's proven standard materials and methods. No part of the external casing (except for areas within one foot of a casing penetration) shall reach a temperature exceeding 30 degrees C (86 degrees F) above ambient. Field-repair hot spots exceeding requirements.
    g. Provide water wash troughs and drains (piped to accessible point) on both sides of lower drum to allow cleaning of exterior of convection tubes.

G. Factory Inspection and Tests:

1. Pressure Vessel Inspection and Certification: Inspect and certify the completed boiler assembly in accordance with the requirements of the ASME BPVC Section I. Submit four copies of completed ASME Form P-3 for each boiler.
2. Inner Casing Pressure Test: Perform test after erection of the boiler pressure parts and inner casing. Seal boiler openings air-tight and pressurize the furnace and convection area to 2.5 kPa (10 inches of water) minimum. Check all welded joints with soap solution. Seal all leaks by rewelding. The inner casing shall be assumed to be tight when it holds pressure for 10 minutes with a loss not exceeding 10 percent. Test shall be certified by manufacturer and may be witnessed by a Government representative.

H. Finish: Provide surface preparation, heat resistant prime and two finish coats using standard color of boiler manufacturer.

2.2 FLEXIBLE TUBE BOILER

A. Packaged water tube, industrial-class, flexible tube, five or six-pass, high pressure steam boiler. //Factory// //Field// assembly. Natural gas and No. 2 fuel oil firing.

B. Service: Continuous generation of steam in conformance to the specified performance requirements with feedwater supply at 100 degrees C (212 degrees F).

C. Performance:

1. Steam output quantity: Refer to drawings.
2. Steam output quality, 99 percent minimum at all steam flow rates. Based on water quality in boiler of 3500-ppm maximum total solids, 15-ppm maximum suspended solids, 700-ppm maximum alkalinity.
3. Minimum Efficiency at Required Maximum Output:
   a. Natural Gas Fuel (37.3 MJ/cubic meter) (1000 Btu/cubic foot): 80 percent at 15 percent excess air.
   b. Fuel Oil (ASTM D396 Grade 2): 82 percent at 15 percent excess air.

D. Boiler Size:

SPEC WRITER NOTE: Previous requirements for a boiler to have a minimum heating surface area of 470 square centimeters per kW (5 square feet per boiler horsepower) are omitted here, because manufacturers generally agree that this

is an obsolete requirement that unnecessarily increases boiler cost.

1. Heating Surface: Provide surface area necessary to obtain scheduled heating performance.
2. Combustion Volume (Furnace Volume): Heat release at full load shall not exceed 828,000 watts per cubic meter (80,000 Btu/h per cubic foot). Combustion volume limits shall not extend beyond first plane of entry into convection tubes. Steady constant direct contact or impingement of the flame on any surface is prohibited.

E. Minimum Design Pressure, 1034 kPa (150 psig).

F. Construction:

1. Codes: Comply with ASME Boiler and Pressure Vessel Code, Sections I, II, VII, and IX.
2. //Design shall accommodate thermal expansion and seismic shocks (when located in seismic area, based on code requirements for that area).//
3. No element of the boiler or accessories shall be overstressed, displaced, or have cracks, broken welds or excessive deflection when in specified operation// or subjected to seismic shock (in seismic area)//. All vertical elements of the boiler and accessories shall be plumb and all horizontal elements shall be level. There shall be no leakage of water, steam, combustion gas or flue gas.
4. All furnace surfaces shall be water cooled tubes or refractory.
5. Base Frame: Design for mounting on flat concrete base. All elements shall be level and square. Provide attachments for anchorage to concrete foundation.
6. Provide lifting lugs and jacking pads.
7. Drums: Steam drum shall be sized and include stainless steel drum internals to provide the required steam quality at all steam demands and when steam demand varies 25 percent of boiler capacity instantaneously. Equip steam drum and bottom drum with elliptical handholes on each end. Equip all handholes with properly fitted steel yokes, bolts, nuts, and non-asbestos gaskets. Provide access to all handholes clear of piping, valves.
   a. Drum Piping Connections:
      1) Flanged, except threaded are permitted for pipe sizes less than 65 mm (2-1/2 inches).

SPEC WRITER NOTE: Steam nozzle forces and moments imposed by connecting piping must be scheduled on the drawings.

2) Steam nozzle shall be 2070 kPa (300 psig) ANSI flanged. Design nozzle and drum assembly to withstand forces and moments imposed by connected piping. Studding nozzle is prohibited.
3) Locate boiler manual steam vent to permit access to gate valve from platform located above boiler.
4) Locate safety valve outlets to permit straight run of vents through roof and to permit valve handle access from platform located above boiler.
5) Water column (including primary low water cutoff).
6) Auxiliary low water cutoff (separate connections from water column).
7) Connections for boiler feedwater, chemical admission, combined continuous blow down and water sampling. Locate as shown on the drawings. Feedwater connected to downcomer is acceptable.
8) Bottom drum blowoff.
9) Water level control sensor connections.
10) Pressure gauge and pressure switch connections.

b. Drum Internals:
1) Stainless steel steam separator to meet steam quality requirements.
2) Boiler feedwater admission system to properly distribute feedwater if feedwater is connected to steam drum.
3) Chemical feed piping to permit infusion of mixture of water treatment compounds along entire length of drum by continuous feed system.
4) Continuous blowdown and water sampling system as combined unit designed to collect water along entire length of drum.
5) Bottom drum blowoff system to properly collect sediment from bottom drum and to permit complete collection of sediment and drainage.

8. Tubes:
a. Seamless or electric resistance welded steel, ASTM A178/178M, Grade A, 2.4 mm (3/32 inch) minimum thickness, outside diameter 40 mm (1-1/2 inch) or greater. Uniform internal area.

b. Tubes shall be welded to tapered ferrule fittings, and this assembly shall press fit into tapered holes in the drums and be secured by bolted clamping system that requires no tube to drum welds. There shall be no leakage.

c. Furnace walls, side, top and bottom shall be enclosed by straight tubes that are uniformly tangent to each other. No furnace seal shall be made by the mating of two hairpin bends. Maximum allowable misalignment of tubes 6 mm (1/4 inch). Furnace gases shall travel the entire furnace before entering the convection area; no leakage between furnace tubes from the furnace into the convection section.

9. Refractory: Refractory quality and temperature characteristics shall be suitable for long term service at the maximum operating conditions and shall be boiler manufacturer’s experience-proven selection. Incorporate refractory systems in non-water-cooled areas of furnace and to seal interfaces between combustion and convection areas. Repair and replacement of refractory shall be possible without alteration to pressure parts.

10. Casing, Setting and Insulation:

a. Provide sealed double wall casing panel system with insulation between the walls. Panel system shall bolt to the boiler frame allowing removal of casing by removing bolts. The inner wall of the casing system shall be sealed to contain the combustion gases and prevent the combustion gases from coming in contact with the outer casing.

b. Design casing at the combustion gas outlet to receive approved stack or breeching transition section as shown. Refer to plans for details of stack arrangement.

c. Provide furnace access door in casing near the furnace floor. Use of the burner throat for access is prohibited. Equip furnace access door opening with refractory, backed up by insulation and airtight cover system.

d. Provide observation port in rear wall of furnace located to permit observation full area of burner. Furnish port with clear and tinted interchangeable glass.

G. Factory (or Field, for Field-Erected Boilers) Inspection and Tests:

1. Pressure Vessel Inspection and Certification: Inspect and certify the completed boiler assembly in accordance with the requirements of

the ASME BPVC Section I. Submit four copies of completed ASME Form P-3 for each boiler.

SPEC WRITER NOTE: Confirm the test pressure stated below with manufacturers. Test pressures of 1525 kPa (5 inches WG) are standard for some flexible tube boiler sizes.

2. Inner Casing Pressure Test: Perform test after erection of the boiler pressure parts and inner casing. Seal boiler openings air-tight and pressurize the furnace and convection area to 2.5 kPa (10 inches of water) minimum. The casing shall be assumed to be tight when it holds pressure for 10 minutes with a loss not exceeding 10 percent. Test shall be certified by manufacturer and may be witnessed by a Government representative.

H. Finish: Provide surface preparation, heat resistant prime and two finish coats using standard color of boiler manufacturer.

2.3 BOILER TRIM (ACCESSORIES)

A. Conform to ASME BPVC Section I. Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT, for operation of water level and steam pressure controls.

B. Steam Safety Valves:

1. Provide two or three on each boiler. Capacities certified by National Board of Boiler and Pressure Vessel Inspectors (NBBI).
2. Type: Angle pattern, flanged or threaded inlet, flanged or threaded side outlet, lifting lever, bronze or cast-iron bodies, stainless steel trim, dual control rings. Valves with bronze bodies shall have EPDM O-ring seat seals. Valves with cast iron bodies shall have lapped seats.
3. Settings and Adjustments: Factory set, sealed, and stamped on nameplate. Set pressures as shown. Lowest set pressure shall not exceed normal operating pressure by more than 207 kPa (30 psig). Provide 34 kPa (5 psig) difference in setting between each of the valves.

C. Steam Pressure Gauge:

1. Construction:
   a. Case: Surface-mounting, bottom or back connection, threaded ring, blowout disc in rear.
   b. Dial: 200 mm (8 inch) minimum diameter, non-corrosive, black markings on white background.

c. Measuring Element: Bourdon tube designed for steam service.

d. Movement: Stainless steel, rotary.

e. Pointer: Micrometer adjustable, black color.

f. Window: Laminated safety glass, or plastic.

2. Accuracy: Full span, 1/2 percent.

3. Range: //0 to 1200 kPa// //0 to 175 psig// //0 to 2070 kPa// //0 to 300 psig//.

4. Installation: Stop valve, steel piping, valved blowdown, siphon, union at gauge, valved connection for inspector's gauge. Mount gauge on sheet metal panel affixed to front of boiler. Use spacers between panel and gauge to permit operation of blow-out disc.

D. Water Column with Water Level Controller and Indicator:

1. Type: Conductivity probe type water level sensing, tilted prismatic gauge glass with illumination, 1724 kPa (250 psig) steam minimum design.

2. Conductivity Probes: Stainless steel with virgin Teflon insulation, ac power. High water alarm, low water alarm, primary low water cutoff, grounding probe. Low water alarm point higher than low water cutoffs. High and low alarms operate bell and warning lamp on boiler control panel but do not cause a burner shutdown.

3. Gauge Glass - Prismatic: Single or double (offset) tilted or vertical prismatic tempered borosilicate reflex units of sufficient length to include all low water cutoff points and high-water alarm point without discontinuity. Provide gauge illuminator, mounted vertically, designed to direct light at gauge only. Locate in front of gauge. Do not block view of gauge from personnel standing 1800 mm (6 feet) in front of burner. Provide chain-operated 1/4 turn gauge valves. Extend chains to within 1800 mm (6 feet) of the floor.

E. Auxiliary Low Water Cutoff:

1. Type: Float chamber with float-actuated sealed snap switch. Water piping connections to the steam drum shall be independent from other devices such as the water column.

2. Construction:

a. UL listed.

b. Float chamber shall have drain connection.

c. Packless construction with pivot and bearing point remote from high temperature areas.

d. Design for 1724 kPa (250 psig) steam.

F. Low Water Cutoff Shunt Switches: Provide two separate non-latching pushbutton controls, one to short-circuit probe-type primary low water cutoff and the second to short-circuit the auxiliary low water cutoff when each is blown down. Locate pushbuttons within reach of drain valves for cutoffs.

G. High Steam Pressure Cutouts:
   1. Provide two units with different set points. Unit with lowest set point shall be automatic reset; unit with highest set point shall be manual reset.
   2. Type: Bellows or bourdon tube actuated sealed snap-acting with adjustable set point and adjustable differential pressure (automatic reset unit).
   3. Construction:
      a. UL listed.
      b. Design for 1380 kPa (200 psig) minimum emergency pressure.
      c. Switch position indicator visible without removing cover.
      d. Set pressure range: To 110 percent of required set pressure.
      e. Provide set point indicators with graduated scales for set point and differential pressure that are visible without removing cover.
   4. Mounting: Pipe directly to boiler steam drum or to water column. There shall be no valves between cutouts and steam drum. Provide siphons at each switch to protect bellows from high temperature.
   5. Set Points:
      a. Automatic Reset Unit: Refer to boiler schedule shown on the drawings.
      b. Manual Reset Unit: 34 kPa (5 psig) higher than automatic reset cutout but below safety valve set pressure. Subtractive differential not to exceed 69 kPa (10 psig).

H. Feedwater Control Valve:
   1. Type: Single-seated, cage guided, balanced valve plug, or characterized rotary valve, designed for throttling service. Equal-percent valve flow characteristic. Electric actuator with positioner.
   2. Performance: Refer to schedules on drawings for pressure, temperature and flow requirements. If not scheduled, flow capacity shall be 125 percent of maximum boiler steam flow with a maximum pressure drop of 34 kPa (5 psig). Maximum seat leakage at shut-off

shall not exceed 0.01 percent of maximum valve capacity (FCI 70-2, Class IV).

3. Construction – Plug Type:
   a. Body Type: Cast iron or bronze, flanged for 65 mm (2-1/2 inch) and greater pipe size, threaded for 50 mm (2 inch) and less pipe size, rated for 1724 kPa (250 psig), 138 degrees C (280 degrees F) minimum.
   b. Plug, Cage, Seat Ring: Replaceable, hardened stainless steel.
4. Construction – Rotary Type:
   a. Three-piece body, cast steel or bronze, flanged for 65 mm (2-1/2 inch) and greater pipe size, threaded for 50 mm (2 inch) and less pipe size, rated for //1724 kPa (250 psig), 138 degrees C (280 degrees F) minimum// //2070 kPa (300 psig) 138 degrees C (280 degrees F) minimum//.
   b. 316 stainless steel ball and stem, Polyfil seat, TFE coated stainless steel seal.
5. Valve Sound Levels: Conform to Section 23 05 51, NOISE AND VIBRATION CONTROL FOR BOILER PLANT.
6. Actuators and Controllers: Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.

2.4 BURNER AND FUEL TRAINS

SPEC WRITER NOTES:
1. Low excess air operation should be specified on units greater than 4 kg/sec (30,000 lb/hr) steam output.
2. Delete low NOx requirements except in localities where required by air emissions authorities.
3. Only natural gas and No. 2 fuel oil should be fired on flex tube type boilers.
4. Steam atomizing burners are only available on D-type boilers.

A. Burner Type: Combination natural gas and fuel oil, packaged, forced draft, single burner, modulating firing, register type on D-type boilers//, and variable speed forced draft fan//. Interrupted igniter (pilot), electrically ignited, natural gas and propane. //Design for low excess air operation.// //Design burner for low NOx emissions.// Burner shall be tested by the boiler manufacturer.
   1. Gas Burner: Ring type with multiple ports and spuds, or spud type.

2. Oil Burner: Gun type, inside mix, //steam or// low pressure air atomizing.
3. Igniter (Pilot): Interrupted, electrically ignited, natural and LP (propane) gas.
4. Burner changeover from one fuel to another shall not require any disassembly and reassembly of any part of the burner or fuel train. Fuel oil guns shall be a permanent part of the burner or shall easily slide into place in the burner.

B. Service:

1. Continuous long-term operation at all firing rates on each fuel listed under PROJECT CONDITIONS in 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 and heating values.
2. Operate at all loads on any one fuel without any manual changes to burners, fuel trains or fuel pressures, atomizing media trains or pressures.
3. Igniter (Pilot) Fuels: Normal fuel will be natural gas. Propane will be used if there is an interruption in natural gas service.

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 within 150 mm (6 inches) of diffuser.
   b. Flame stable with no blowoff from the burner or flashback into the burner. No pulsations.
   c. Throat refractory shall be sufficiently heated to provide stable flame on gas firing.
   d. No deposits of unburned fuel or carbon at any location.
   e. No carryover of flame beyond the end of the first pass (furnace).
   f. Flame impingement on furnace tubes or refractory is prohibited.
4. Main Burner Operation:

SPEC WRITER NOTE: Turndown varies with boiler size and for controlled emissions versus uncontrolled emissions. Turndown may be 10:1 on gas with uncontrolled emissions, but may be as low as 5:1 on gas with controlled emissions.

a. Minimum turndown //10:1// //8:1// //5:1//.

b. Utilize full travel of fuel control valve characterization cams (if cam type valve is utilized).

c. Operate at all loads on any one fuel without any manual changes to burners, fuel or atomizing media trains or pressures, air train.

SPEC WRITER NOTE: Choose paragraph “d” for normal excess air burners and “e” for low excess air burners. Utilize low excess air only on larger boilers, approximately 4 kg/sec (30,000 lb/hr) steam output and above.

d. 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 to 39	15 to 35
40 to 100	15 to 25

e. Excess Air in Flue Gases (Low Excess Air Burners) with Oxygen Trim at Null Position:

Boiler Steam Output Percent of Maximum Required Capacity	**Percent Excess Air Allowable Range**
Below 20	10 minimum
20 to 39	5 to 15
40 to 100	5 to 10

f. Performance at any load point shall be repeatable after increasing or decreasing the firing rate. Repeatability plus or minus 2 percent excess air, at 20 percent and higher boiler loading except excess air must remain within ranges specified above.

SPEC WRITER NOTE: Oxygen trim control should be specified on boilers that have parallel positioning combustion controls.

5. //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.//

6. Oil Atomization: If plant is cold (no steam available), and if steam-atomizing burners are provided, light-off shall be with compressed air atomization media supplied by house compressor. Boiler shall operate with combustion controls on "manual" and continuously generate at least 13 percent of the maximum rated steam flow with input compressed air at 550 kPa (80 psig) and a maximum of 0.8 standard cubic meters per minute (30 SCFM). Each burner must include a dedicated air compressor system furnished by the burner manufacturer.
7. 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.

SPEC WRITER NOTE: Engineer must review local emissions rules and revise the following paragraphs as necessary.

8. 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.

SPEC WRITER NOTE: Delete NOx requirements except where required by local air emissions authorities. Insert local NOx emissions limits if applicable. If local emissions rules express the requirement in a different way, revise the following paragraph to conform. The VA prefers to avoid any requirements for low NOx limits (30 ppm or lower), unless local air emission regulations such, because of typically adverse effects turndown, capacity, and efficiency.

   c. NOx: // // ppm maximum, corrected to 3 percent oxygen, dry basis on natural gas //and // // ppm maximum for low nitrogen No. 2 fuel oil//.

D. Burner Design, Construction and Arrangement:
   1. Burner Access (Main Burner and Igniter): Arrange fuel trains, controls and other devices so that they do not interfere with the removal and replacement of burner parts.
   2. Arrangement of Fuel Trains: All devices shall be accessible for maintenance or replacement without removal of other devices. Do not mount any piping or devices within 600 mm (2 feet) of boiler side and top casings, unless the casing can be removed without removal of

gas train components. Do not attach any piping or devices to boiler casings.

3. Coatings: Provide surface preparation, heat resistant prime and two finish coats using standard color of boiler manufacturer.
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 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.
   e. Motor: TEFC or open drip proof, non-overloading under all fan operating conditions, design for 40 degrees C (104 degrees F) 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.
   f. Damper: Design to provide accurate control of excess air with minimum hysteresis. //On variable speed systems, the damper shall operate across all 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 front and rear 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. Flexible metal conduit must be limited to 900 mm (3 feet) in length, unless additional length is required for door or burner swing. Refer to Section 26 05 33, RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS.
8. Factory Testing (Factory-Assembled Boilers): Mount burner and controls on boiler at factory and fire-test to verify proper operation, including flame safeguard and safety interlock operation. All safety device testing shall be performed in accordance with manufacturer requirements, these contract documents, the VHA Boiler Plant Safety Devices Testing Manual, and the most stringent requirements shall apply.

SPEC WRITER NOTE: Delete any fuel trains not required. Determine if the natural gas supplier has any special requirements that must be incorporated in the main or igniter fuel trains.

E. Natural Gas Main Fuel Valve and Piping Train:
1. Arrangement: Comply with 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 gauge, pressure regulator, valved connection to pilot burner fuel train, flow meter (if required), pressure gauge, low pressure switch, two automatic safety shut off valves, valved leak test, high pressure switch, fuel flow control valve, plug valve, pressure gauge, 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 WG). Provide vent with cock for relieving pressure in filter.
3. Pressure Regulator:
   a. Type: 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, 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. Purpose of high performance regulator is to provide more accurate flow control and thus greater burner efficiency and to allow set points of high and low gas pressure switches to be closer to the normal operating pressure.
   c. Performance: Coordinate with burner requirements. Lock-up pressure shall not exceed 1.5 times regulated pressure. Coordinate speed of response with opening and closing time of automatic safety shut-off valves so that controlled pressure will be maintained during the opening and closing of the safety shut-off valves. The outlet pressure droop from low fire to high fire shall not exceed 5 percent of the set pressure.
   d. Construction, Main Valve: Cast iron body, replaceable plug and seat.
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.

SPEC WRITER NOTE: Valves with longer opening times often do not allow the main burner to ignite within the specified (and code required) 10 seconds trial for main flame.

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 greater, flanged ends; valves 50 mm (2 inches) and less threaded ends; position indicator showing open and shut, visible from front or side of boiler. Aluminum seating surfaces are prohibited. Proof of closure interlock switch on each valve. Proof of closure electrical circuit shall include non-latching push button interrupter for testing the circuit. Valved leak test fittings before and after each valve.

e. Approval: FM approved, UL listed for burner service.

SPEC WRITER NOTE: VA safety device testing program has revealed problems with auto safety shut off valves other than Maxon. Problems included proof of closure switches, and pressure pulses upon closure that affect the high gas pressure switches.

f. Proof of Closure Test: Provide non-latching push button control in the proof of closure circuit to interrupt the circuit for testing.

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 paragraph, BURNER MANAGEMENT (FLAME SAFEGUARD CONTROL) SYSTEM WITH SAFETY INTERLOCKS AND ACCESSORIES in Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.

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). Valve with adjustable characterization cam required on single point positioning control systems.
   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. Construction: If provided, characterization cam shall be shaped by at least twelve adjustment screws.
9. Pressure Gauges, Flow Meter: Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.

F. Fuel Oil Valve and Piping Train:
1. Arrangement: Comply with 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 gauge, pressure regulator (if required by burner furnished), low pressure switch, high pressure switch, meter (if specified), oil flow control valve, valved drain, automatic safety shut off valve, valved leak test, automatic safety shut off valve, valved leak test, manual shut off valve, pressure gauge, burner.
2. Filter: Permanent edge-type elements, cleanable by rotation of a handle without interruption of flow. Filter element spacing 0.1 mm (0.004 inch). Pressure rating shall exceed upstream safety relief valve set pressure plus accumulation. Maximum pressure loss 21 kPa (3 psig) at high fire. Provide plugged drain. Temperature rating 121 degrees C (250 degrees F) on heated oil service.
3. Automatic Safety Shut-Off Valves:
   a. Type: Motorized-opening, spring closing, controlled by burner control system. Two 2-way valves required on No. 2 oil service; one 3-way and one 2-way required on heated oil service or by burner design.
   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. Temperature rating 121 degrees C (250 degrees F) on heated oil service.

SPEC WRITER NOTE: Seven seconds, or less, valve opening timing is required so that burner will reliably ignite within the 10 seconds trial for main flame allowed by NFPA 85.

c. Performance: Timed opening of eight 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. Proof of closure interlock switch on each valve. Provide non-latching push button switch in proof of closure circuit to interrupt circuit for testing.

e. Approval: FM approved, UL listed for burner service.

f. Provide 10 mm (3/8 inch) relief valve on piping between safety shut-off valves, 1380 kPa (200 psig) rating, tight shut-off. Set pressure lower than pressure rating of safety shut-off valves. Provide valved leak-test connections between the two safety shut off valves and after the second safety shut off valve.

4. Pressure Switches: Refer to the paragraph, BURNER MANAGEMENT (FLAME SAFEGUARD CONTROL) SYSTEM WITH SAFETY INTERLOCKS AND ACCESSORIES in Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT. Set points shall be as required by the burner manufacturer. If there are no requirements, the set points shall be within 50 percent of the controlled pressure.

5. Fuel Flow Control Valve:

a. Type: Throttling, controlled by combustion control system (Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT). Valve with adjustable characterization cam required for single point positioning control systems.

b. Performance and Service: Control fuel flow in exact proportion to combustion airflow over the entire firing range of the burner. Pressure rating shall exceed oil pump safety relief valve pressure setting plus accumulation.

c. Construction: If provided, characterization cam shall be shaped by at least twelve adjustment screws.

d. Option: Burner manufacturer's standard fuel flow control system may be utilized for single point positioning systems if it has an adjustable characterization feature equal to the flow control valve specified.

6. Oil Guns and Nozzles: On steam atomizing systems, provide two special nozzles if necessary for cold start on compressed air atomization. Provide special guns if nozzles do not fit guns furnished for steam atomizing nozzles.
7. Provide oil pump arranged and piped to provide automatic drainage of oil gun when burner is shut down manually. Not required when oil gun is less than 600 mm (2 feet) long.
8. Pressure Gauges, Thermometers, Flow Meter: Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.

SPEC WRITER NOTE: Verify the existence and pressure/flow capability of the house oil pumps and relief valves.

9. Boiler/Burner-Mounted Oil Pump and Relief Valve: Do not provide. House pumps are provided that include relief valves.

SPEC WRITER NOTE: Retain the following paragraphs for D-type boilers only.

G. //Steam Atomizing Valve and Piping Train (with Compressed Air for Cold Start):
1. Steam/Air Selection: Provide flexible hose to permit selection of steam or compressed air. Refer to Section 23 21 11, BOILER PLANT PIPING SYSTEMS. Hose connections shall be within 1800 mm (6 feet) of the floor. Permanent interconnection of steam and compressed air piping is prohibited.
2. Differential Pressure Control Valve:
   a. Type: Spring loaded, diaphragm-actuated, controlled by oil pressure at burner.
   b. Service: Provide control of steam or air pressure to the oil burner. Base valve size on steam and air pressure available at valve inlet. Valve body shall be rated for 1380 kPa (200 psig) steam pressure.
   c. Performance: As required by burner.
   d. Construction: Cast iron body, stainless steel trim, double stainless-steel diaphragms with vented space between to separate oil and steam or air.
3. Pressure Switches: Refer to paragraph, BURNER MANAGEMENT (FLAME SAFEGUARD CONTROL) SYSTEM WITH SAFETY INTERLOCKS AND ACCESSORIES in Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.

4. Shut-Off Valve:
   a. Type: Motorized or solenoid opening, spring closing, controlled by burner control system.
   b. Service: Provide open-shut control of atomizing media flow to burner. If solenoid valve requires a minimum differential pressure for operation, coordinate pressure requirements with available pressures. Valve body shall be rated for 1034 kPa (150 psig) steam, dead-end shut-off.
   c. Approval: UL listed.//

H. Low Pressure Air Atomizing System:
   1. Complete system for each burner, furnished by burner manufacturer, including compressor and drive, air filter, low pressure switch and all piping systems. Where compressor is driven by separate motor and coupling drive system, provide all equipment including motor, coupling, compressors, starter, wiring and protection.
   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 proving power supply to motor.
   4. 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.
   5. Pressure Gauges and Pressure Switches: Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.

I. Igniter (Pilot) Fuel Valve and Piping 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 gauge, 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 gauge, 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 WG). 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. (Refer to the schematic diagrams shown on the drawings).
   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: LP gas regulator must be designed for 861 kPa (125 psig) maximum pressure.
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 138 kPa (20 psig) 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 ultraviolet (if provided) 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 Gauges: Refer to Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.

2.5 BURNER MANAGEMENT CONTROL (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 free standing NEMA 4 enclosure. 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.

SPEC WRITER NOTE: Delete the following paragraph if not required in the project.

2.6 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.

C. Performance: Refer to schedules shown on the drawings. Coordinate input flue gas temperatures with data from boiler manufacturer.

D. Construction:

SPEC WRITER NOTE: Use ASME BPVC Section I for D-type boilers and ASME BPVC Section VIII for flexible tube boilers.

1. Comply with ASME BPVC Section //I// //VIII//. Design unit to permit operation with no water in the tubes at the temperature listed below.
2. Design Pressure:
   a. Water tubes, 2070 kPa (300 psig) minimum.
   b. Inner casing, 2.5 kPa (10 inches WG) minimum.
3. Design temperature 371 degrees C (700 degrees F) minimum.

4. Tubes: ASTM A269/A269M Type 316 stainless steel tubing. Helical-wound non-serrated Type 316 fins continuously welded to tubes. Headers of Type 316 seamless carbon steel tubing, Schedule 40 minimum. 2070 kPa (300 psig) flanged piping connections. Gravity drainage. 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 (1/2 inches).
5. Casing: Inner and outer casing with insulation between. 75 mm (3 inch) angle flanges on flue gas inlet and outlet for attachment of breeching and stack.
   a. Inner Casing, 3.5 mm (10 gauge) thick Type 316 stainless steel, all welded. Stainless steel angles for breeching attachment to casing. Entire casing system 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 (27 gauge) thick.
   d. Access and Inspection Openings: Insulated, 406 mm (16 inches) square minimum.
6. Design to permit field replacement of tubes without removing unit from stack. Provide bolted access doors for tube replacement.

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 1896 kPa (275 psig) gauge.
2. Inlet and Outlet Transitions: Designed and furnished by economizer manufacturer.

SPEC WRITER NOTE: Consult with economizer manufacturers on need for feedwater preheat system to provide protection from "cold-end" corrosion in the economizer and stack. Generally, on natural gas and No. 2 oil firing, with 108 degrees C (226 degrees F) feedwater, a preheat system will not be necessary. If a preheat system is required, provide a specification.

F. Factory Test and Inspections: Inspect the completed economizer assembly in accordance with the ASME BPVC Section I. Certify the inspection and submit four copies of the completed ASME Form P-3 for each economizer.

2.7 TOOLS

A. Oil Burner Vise and Wrenches: Deliver to the Contracting Officer's Representative (COR) for mounting by VA personnel. Furnish only if burner requires wrench not found in commercial hardware store.

B. Device for Hanging Oil Burner Guns: Space for total number of guns furnished. Deliver to the COR for mounting by VA personnel. Furnish only if oil gun must be removed from burner when firing gas.

C. Burner throat sweep to provide proper shape for reconstruction of castable refractory throats. Not required for throats made of preshaped tiles.

2.8 SPARE PARTS

A. Fuel Trains:

1. One assembly of electrodes, transformer, and high voltage cable with end connectors for the igniter.
2. One of each type and size of main and pilot fuel motorized and solenoid automatic safety shut-off valves and automatic vent valves.
3. //One atomizing steam admission solenoid valve.//
4. Complete set of filter elements and gaskets for each gas filter for each boiler.
5. Complete set of all gaskets for each edge-type oil filter for each boiler.

B. Boiler, Burner, Trim, Feedwater Control Valve:

1. Drum handhole gaskets, three complete sets for each boiler.
2. One clear lens and one tinted lens for each furnace and burner observation port on each boiler.
3. Sufficient glass inserts and gaskets to re-equip all water level gauge glasses on one boiler.
4. One set of drive belts for each belt-driven apparatus on each boiler.
5. One gallon oil for burner-mounted atomizing air compressors.
6. If cast refractory plug is utilized for furnace access, provide sufficient refractory material to rebuild one plug for each boiler.
7. One set of all gaskets for each type of oil gun.
8. One oil gun and nozzle of each type and size utilized.
9. Valve and actuator complete for electrically-operated feedwater control valve.

PART 3 - EXECUTION

3.1 INSTALLATION

A. If an installation is unsatisfactory to the COR, the Contractor shall correct the installation at no additional cost or time to the Government.

B. Boiler, Burner and Economizer Access Openings: Arrange all equipment and piping to allow access to openings without disassembly of equipment or piping.

C. Drainage Facilities for Boiler Water Column, Gauge Glass, Low Water Cutoffs, Water Level Alarms:

1. Refer to paragraph //D-TYPE WATER TUBE BOILER// //FLEXIBLE TUBE BOILER// and BOILER TRIM (ACCESSORIES). After individual drain valves, combine all drains into one pipe with a sight flow indicator, gate valve and check valve. Pipe to boiler blowoff line.
2. Locate and orient sight flow indicator on common drain line so that one person can view the fluid flow while simultaneously operating drain valves and low water cutoff shunt switch.

D. Boiler Drum Level Transmitter for Feedwater Regulator System:

1. Provide three-valve isolation and equalizing system rated for 1380 kPa (200 psig), 182 degrees C (360 degrees F).
2. Provide valved drain on all level sensing lines. Connect to water column drain system upstream of sight flow indicator.

E. Boiler Casing Flashing: Flash or seal all pipe penetrations in casing at steam drum to prevent leakage of water into boiler insulation.

F. Air and steam hose connections for selection of atomizing media shall be within 1800 mm (6 feet) of the floor.

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. Inspect internal surfaces for cleanliness. Then, drain and

refill boiler with softened and treated water or place boiler in dry storage as specified below.

2. Refer to the paragraph, INSPECTION AND TESTS “Internal Inspection of Pressure Parts and Furnace”, for the requirements for cleaning the boiler after the operational tests are completed.

C. Protection from Corrosion:

1. Protect the boilers from fireside and waterside corrosion at all times.
2. Dry Storage: When the boilers are not filled with water, protect the watersides and firesides with a dry storage method recommended by either the boiler manufacturer or the ASME BPVC 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 BPVC Section VII. If boilers are not fired for equipment adjustment and testing for more than one month, drain the boilers and place in dry storage.
4. Chemical Treatment: The quality of the water in the boilers shall be maintained by a professional water treatment organization. This organization shall provide onsite 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 COR. The Contractor shall provide all chemicals, labor and professional services until the boilers have been accepted by the Government for operation. All chemicals utilized must conform to FDA Regulation CFR 21, 173.310, guidelines applicable for steam used in food preparation.

3.3 INSPECTIONS AND TESTS

A. The following tests and demonstrations, except pretests, must be witnessed by the COR or their representative and must prove that boilers, economizers, burners, controls, instruments, and accessories comply with requirements specified. Refer to Section 23 08 11, DEMONSTRATIONS AND TESTS FOR BOILER PLANT for general requirements. When test results are not acceptable, corrections must be made and the test repeated at no additional cost or time to the Government. Pretests do not require the presence of the COR.

B. Condition of Boiler and Economizer (if provided) After Delivery, Rigging, Placement: After setting boiler on foundation and placing

economizer on supports, and prior to making any connections to boiler and economizer, Contractor and COR jointly will inspect interior and exterior for damage. Correct damage by repair or replacement to achieve a like new condition. After completion of repairs, perform air pressure test of the boiler casing. The Contractor shall conduct these tests at no cost to the Government.

C. Hydrostatic Tests:
   1. Boiler, Economizer (if provided): Conduct tests after the equipment is installed and connected for operation and prior to initial firing. Contractor shall provide inspector certified by National Board of Boiler and Pressure Vessel Inspectors (NBBI). Test pressure shall be 150 percent of the design pressure of the boiler held 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 the tests are complete.

D. Boiler Steam Safety Valves:
   1. Test each safety valve set pressure and blowdown pressure with boiler steam pressure. Perform accumulation test to verify that safety valves have sufficient capacity to relieve full boiler output at maximum firing rate of burner. 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 3 percent of set pressure for set pressures over 480 kPa (70 psig).
   3. Valve Blowdown Tolerance: Reset at not less than 6 percent below set pressure of valve with the lowest set pressure. Minimum blowdown 2 percent of the set pressure.
   4. Accumulation Test: With burner at high fire, the boiler pressure shall not rise more than 6 percent above the set pressure of the

safety valve with the highest pressure setting and no more than 6 percent above the maximum allowable working pressure of the boiler.

5. Make repairs and adjustments in manner recommended by National Board of Boiler and Pressure Vessel Inspectors (NBBI) NB 23, Inspection Code. Retest valves after completion of repairs and adjustments.

E. Burner Management Control (Flame Safeguard) System:

1. Demonstrate set points and operation of all control, interlock, monitoring 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 devices have been pretested (Refer to Section 23 08 11, DEMONSTRATIONS AND TESTS FOR BOILER PLANT.
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, Computer Workstation (if provided):

1. Perform tests on each boiler on all main burner fuels.
2. If required by local emissions authorities, provide the services of a testing firm to determine the NOx and carbon monoxide at boiler loads as required by the emissions authorities. Test firm shall be acceptable to emissions authorities.
3. Test No. P-1:
   a. Operate boiler on each fuel, with economizer (if provided) in service, and record data for at least six evenly spaced steam outputs between low fire start and 100 percent of full steam output, and in the same sequence back to low fire. Demonstrate performance and efficiency required by paragraphs, BURNER AND FUEL TRAINS and FLUE GAS ECONOMIZER and by boiler and economizer equipment lists on drawings.
   b. Demonstrate proper operation of combustion controls, draft controls (if provided), feedwater level controls, instrumentation and computer workstation programming (if provided). 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.

4. Test No. P-2:
   a. Demonstrate sound level of burner system and atomizing air compressor (if provided).
   b. Test point shall be at pre-purge, and firing 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 pre-purge and at 100 percent of maximum boiler load with combustion air control at maximum position.
   b. Current draw shall not exceed full load current stamped on the motor nameplates.
   c. This test may be combined with Test No. P-1.
6. Test No. P-4: Operate boiler on both fuels, flue gas oxygen trim in service on automatic control, and record data at a minimum of 6 evenly spaced steam output points between low fire start and full steam output and in the same sequence back to low fire. Demonstrate oxygen trim control performance required by Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.

   SPEC WRITER NOTE: Omit Test P-5 if flue gas oxygen trim is not provided.

7. Test No. P-5: Operate boiler on one fuel, flue gas oxygen trim in service on automatic control, and record data at the following load points: Low fire start, 13, 20, 40, 60, 80, 100, 80, 60, 40, 20 and 13 percent of full steam output. Demonstrate oxygen trim control performance required by Section 23 09 11, INSTRUMENTATION AND CONTROL FOR BOILER PLANT.
8. Test Methods:
   a. Utilize permanent instrumentation systems for data. All instrumentation systems and computer workstation (if provided) shall be operational and in calibration.
   b. Provide portable thermocouple pyrometer furnished and retained by the Contractor to measure stack temperature as a verification of permanent stack temperature instrumentation.
   c. Use portable electronic flue gas analyzer furnished by Contractor to determine constituents of flue gas and stack temperature. Analyzer shall be capable of measuring oxygen in percent with

accuracy of plus or minus 0.5 percent and carbon monoxide in ppm with accuracy of plus or minus 5 percent of reading (Range 0 to 1000 ppm). Obtain oxygen and carbon monoxide readings at each test point. Instrument shall have been calibrated with certified test gases within three months prior to use and immediately after cell replacement.

d. In Test Nos. P-1, P-2, and P-5, 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 test may be furnished by the VAMC hospital systems, by operation of the steam silencer vent system, or by a combination of the above. If variable hospital loads interfere with the testing, conduct tests at night or on weekends when the loads are more stable.

f. Provide 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.

SPEC WRITER NOTE: If NOx emissions requirements are applicable specify testing procedure acceptable to local emissions authorities if it differs from method listed.

i. NOx emissions shall be tested with electronic analyzer reading in ppm. Analyzer shall be calibrated at with certified test gas within three months prior to use and immediately after cell replacement. Analyzer shall be accurate to plus or minus 5 percent of reading.

9. 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 data sheet 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 each screw on the fuel flow valve characterization cam starting at the minimum position, proceeding to the maximum position and returning to the minimum position.
   1) Fuel valve screw number or actuator position.
   2) Steam flow rate (at minimum, 50 percent, maximum firing position only).
   3) Steam pressure: At boiler drum, and at header (at minimum, 50 percent, maximum firing position only).
   4) Fuel Pressures: At burner and also upstream of fuel flow control valve.
   5) Fuel temperature (heated oil only).
   6) Fuel flow rate.
   7) Boiler feed pressure, upstream of feedwater regulator (at minimum, 50 percent and maximum firing positions only).
   8) Boiler feed temperature (at minimum, 50 percent, maximum firing positions only).
   9) Stack temperature: Boiler outlet, economizer outlet.
   10) Flue gas oxygen and carbon monoxide (utilize instrument which has been calibrated with certified test gases).
   11) Flue gas NOx (if limit specified).
   12) Percent excess air.
   13) Opacity of flue gas.
   14) Submaster position.
   15) Flame shape: Note and describe any flame contact with refractory or heating surface.
   16) Combustion air temperature-dry bulb and wet bulb.
   17) Barometric pressure (one reading).

d. Calibrate all pressure gauges prior to the pretest.

SPEC WRITER NOTE: Delete the capacity-efficiency test when the project is for burner replacement on an existing boiler.

G. Capacity - Efficiency Test of Boiler and Burner:

1. Perform test on one of each size boiler in the project, selected by COR, on all main burner fuels.

2. Test No. E-1: Test boiler on each fuel, with no water in economizer (if provided), at full load. Demonstrate performance required by paragraph //D-TYPE WATER TUBE BOILER// //FLEXIBLE TUBE BOILER// and by boiler equipment lists on drawings.
3. Test Methods:
   a. Conform to ASME PTC 4. Use abbreviated input-output and heat balance methods. Utilize ASME Test Forms.
   b. Test Meters and Instruments:
      1) Feedwater Flow Meter: Vortex or turbine-type, totalizing in increments of //10 liters// //10 gallons// or less, pressure rating exceeding feed pump no flow shut-off pressure, temperature rating exceeding normal feedwater temperature, calibrated immediately prior to test by independent laboratory. Calibrate at three points, 10 percent above, 10 percent below, and at the required flow rate at high fire. Furnish calibration data. Remove meter from the line and deliver to COR after tests are accepted.
      2) Fuel Oil Flow Meters: Displacement type, totalizing, smallest reading one liter (one gallon), pressure rating exceeding oil pump safety relief valve set pressure plus accumulation, 121 degrees C (250 degrees F) (if heated oil), calibrated immediately prior to test by independent laboratory. Calibrate at three points, 10 percent above, 10 percent below, and at the required flow rate at high fire. Furnish calibration data. Remove meter from the line and deliver to COR after tests are accepted.
      3) Natural Gas Flow Meter: Utilize permanent meter serving boiler plant.
      4) Steam Calorimeter (for measuring steam quality): Throttling, U-path, temporary instrument, furnished and retained by Contractor, with thermometer that has been calibrated immediately prior to test. Provide one spare calibrated thermometer.
      5) Portable electronic flue gas analyzer as specified for the performance testing.
      6) Thermocouple Pyrometer (for measuring flue gas temperature): Temporary instrument furnished and retained by Contractor, 100

to 400 degrees C (200 to 800 degrees F) range, automatic ambient temperature compensation.

7) Thermometers: Utilize contractor-furnished and retained temporary thermometers and permanent thermometers to measure fuel and air temperatures. All must be calibrated immediately prior to test. Furnish calibration data.

8) Pressure Gauges: Utilize permanent gauges. Calibrate each gauge immediately prior to test. Furnish calibration data.

9) Plant Instruments and Computer Work Station (if provided): Must be calibrated, programmed and in proper operation.

c. Fuel Analyses: The Government will furnish analysis of natural gas. The Contractor must obtain an ultimate type analysis of fuel oil prior to the final boiler tests. Fuel oil analysis must include heating value, specific gravity, viscosity and percent carbon, hydrogen, sulfur, ash, oxygen, and nitrogen. Test by independent laboratory.

d. Duration of each test will be 4 hours after all systems and measured parameters have stabilized.

e. Water quality in the boiler shall be checked immediately prior to the start of the tests. Solids and alkalinity must be adjusted prior to the test to conform to limits listed in paragraph //D-TYPE WATER TUBE BOILER// //FLEXIBLE TUBE BOILER// in Part 2.

4. Pretesting: None required.

H. 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 and any other type of damage or defect.

2. In preparation for the inspection, open all drum handholes and the furnace access opening, drain and clean the interior of all pressure parts and clean all soot and debris from the furnace.

3. Any corrosion, damage or defect shall be corrected to a like new condition in the judgment of the boiler inspector.

4. Hard carbonaceous deposits on heating surface or refractory are evidence of flame impingement and are prohibited. Remove all deposits, make corrections to burners and provide complete retest of boiler and burner performance.

5. After the boiler inspector has approved the boiler, all handholes and furnace access openings shall be closed with new gaskets.
6. Hard carbonaceous deposits in the furnace are evidence of flame impingement. Within one year after acceptance of the boiler for Government operation, the Government will inspect the furnace for the carbonaceous deposits. If deposits are present, the Contractor shall remove them. If tubes or refractory are damaged, the Contractor shall replace them to achieve a like new condition. The Contractor shall make corrections to burners to eliminate the conditions that have caused the problems and shall provide complete retest of boiler and burner performance.

I. Report: Furnish complete written report (three copies) that includes test data, calculations, results compared with requirements, list of personnel, and other pertinent information. Furnish report within three weeks after completion of tests.

3.4 STARTUP AND TESTING

A. Perform tests as recommended by product manufacturer and listed standards and under actual or simulated operating conditions and prove full compliance with design and specified requirements. Tests of the various items of equipment shall be performed simultaneously with the system of which each item is an integral part.

B. When any defects are detected, correct defects and repeat test at no additional cost or time to the Government.

C. //The Commissioning Agent will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the COR and Commissioning Agent. Provide a minimum notice of 10 working days prior to startup and testing.//

3.5 //COMMISSIONING

A. Provide commissioning documentation in accordance with the requirements of Section 23 08 00, COMMISSIONING OF HVAC SYSTEMS.

B. Components provided under this section of the specification will be tested as part of a larger system.//

3.6 DEMONSTRATION AND TRAINING

A. Provide services of manufacturer’s technical representative for //4// // // hour//s// to instruct each VA personnel responsible in the operation and maintenance of the system.

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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