UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2021
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DIVISION 23 - HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)

SECTION 23 52 53.00 20

STEAM BOILERS AND EQUIPMENT (18,000,000 - 60,000,000 BTU/HR)

04/06, CHG 2: 08/18

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USACE / NAVFAC / AFCEC / NASA	**UFGS-23 52 53.00 20 (April 2006)** **Change 2 - 08/18**

Preparing Activity: NAVFAC	**Replace without change** **UFGS-15517N (June 2005)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

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SECTION 23 52 53.00 20

STEAM BOILERS AND EQUIPMENT (18,000,000 - 60,000,000 BTU/HR)
04/06, CHG 2: 08/18

****
NOTE: This guide specification covers the requirements for packaged steam boilers and equipment with gross outputs over 5275 kW 18,000,000 Btu's per hour.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).
****

****
NOTE: These boilers are equipped for oil-, gas-, or oil-and-gas combination firing, as specified.
****

****
NOTE: The following information shall be shown on the project drawings:

1. Dimensions of construction

2. Relationship of materials

3. Quantities, location and capacity of equipment.
****

PART 1 GENERAL

1.1 REFERENCES

****
NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.
****

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ACOUSTICAL SOCIETY OF AMERICA (ASA)

ASA S1.4	(1983; Amendment 1985; R 2006) Specification for Sound Level Meters (ASA 47)

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)

AISC 360	(2016) Specification for Structural Steel Buildings

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC	(2010) Boiler and Pressure Vessels Code
ASME BPVC SEC I	(2017) BPVC Section I-Rules for Construction of Power Boilers
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1
ASME PTC 4	(2013) Fired Steam Generators
ASME PTC 19.5	(2004; R 2013) Flow Measurement
ASME PTC 19.11	(2008; R 2013) Steam and Water Sampling, Conditioning, and Analysis in the Power

Cycle

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2020) Structural Welding Code - Steel
AWS Z49.1	(2012) Safety in Welding and Cutting and Allied Processes

ASTM INTERNATIONAL (ASTM)

ASTM A283/A283M	(2013) Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates
ASTM B88	(2020) Standard Specification for Seamless Copper Water Tube
ASTM B88M	(2020) Standard Specification for Seamless Copper Water Tube (Metric)
ASTM D396	(2019a) Standard Specification for Fuel Oils
ASTM D888	(2012; E 2013) Dissolved Oxygen in Water
ASTM D1066	(2018; E 2018) Standard Practice for Sampling Steam
ASTM D2186	(2005; R 2009) Deposit-Forming Impurities in Steam

FM GLOBAL (FM)

FM APP GUIDE	(updated on-line) Approval Guide http://www.approvalguide.com/

NATIONAL BOARD OF BOILER AND PRESSURE VESSEL INSPECTORS (NBBI)

NBBI NB-27	(1991) National Board Rules and Recommendations for the Design and Construction of Boiler Blowoff Systems

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2020; ERTA 20-1 2020; ERTA 20-2 2020; TIA 20-1; TIA 20-2; TIA 20-3; TIA 20-4) National Electrical Code
NFPA 85	(2019) Boiler and Combustion Systems Hazards Code

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-50504	(Basic) Analyzers, Flue-Gas, Orsat-Type, Portable
CID A-A-50562	(Basic) Pump Units, Centrifugal, Water, Horizontal; General Service and Boiler-Feed: Electric-Motor or Steam-Turbine-Driven
CID A-A-50566	(Basic) Monitoring Devices, Emission, Stack Related
CID A-A-50573	(Basic, Notice 1) Water Softener Unit, Lime-Soda Type
CID A-A-59249	(Basic; Notice 1; Notice 2) Filters, Fluid, Pressure, Feedwater
FS F-B-2902	(Basic; Notice 1) Boilers, Steam Watertube (Bent Tube, Multi-Drum and Cross Drum) Packaged Type (10,000,000 to 125,000,000 BTU/HR Thermal Output Capacity)
FS F-B-2910	(Basic) Burners, Single Oil, Gas, and Gas-Oil Combination for Packaged Boilers (320,001 to 125,000,000 BTU/HR Thermal Output Capacity)
FS F-F-2901	(Basic; Notice 1) Feeders, Boiler Water Treatment, By-Pass and Compound Receiver Types
FS F-P-2908	(Basic; Notice 1) Pumping Units, Condensate, Return; and Boiler Feed Package
FS TT-P-28	(Rev H) Paint, Aluminum, Heat Resisting (1200 Degrees F.)
FS W-H-2904	(Basic; Notice 1) Heaters, Fluid, Deaerating (For Water Only) 1,000 to 1,600,000 Pounds Per Hour Capacity

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910-SUBPART D	Walking - Working Surfaces

U.S. NAVAL FACILITIES ENGINEERING COMMAND (NAVFAC)

NAVFAC MO 225	(1990) Industrial Water Treatment
NAVFAC MO 324	(1992) Inspection and Certification of Boilers and Unfired Pressure Vessels

WATER QUALITY ASSOCIATION (WQA)

WQA S-100	(2000) Household, Commercial, and Portable Exchange Cation Exchange Water Softeners

1.2 SYSTEM DESCRIPTION

Describe the performance or design requirements and tolerances of the complete system. Section 23 52 33.01 20 STEAM HEATING PLANT WATERTUBE SHOP ASSEMBLED COAL/OIL OR COAL.

1.2.1 Heating Surface and Volume Measurements

Submit heating surface and volume measurements, including heat release calculations sufficient to establish compliance of boilers with heat release requirements. Base calculations on the specified efficiency and capacity.

1.3 RELATED REQUIREMENTS

Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS with the following additions and modifications applies.

1.4 SUBMITTALS

****

NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

Choose the first bracketed item for Navy, Air Force, and NASA projects, or choose the second bracketed item for Army projects.

****

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are

[for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Steam Boiler System

SD-03 Product Data

Boiler Efficiency

SD-05 Design Data

Heating Surface and Volume Measurements

Heat Release Calculations

SD-06 Test Reports

Boiler System Start-Up Tests

Submit in accordance with paragraph FIELD QUALITY CONTROLS. Submit detailed written record of the start-up performance, including burner setting data over the entire load range, to the cognizant authority before the Contractor's and sub-contractor's test personnel leave the site.

SD-07 Certificates

Report of Prior Installations

Engineer's Qualification Resume

Start-Up Plan

Start-Up Certification

Boilers

Submit evidence that boilers meet requirements of standards specified below. Include with the certificate of compliance acceptable evidence that standards are met. Acceptable evidence of meeting these standards will be the official UL listing for oil-fired, gas-fired or gas-oil fired boiler assemblies, as applicable, plus the appropriate official ASME symbol stamp.

SD-10 Operation and Maintenance Data

Boilers, Data Package 4

Submit in accordance with Section 01 78 23 OPERATION AND MAINTENANCE DATA. Submit evidence for boiler, boiler controls, instrumentation and feedwater equipment manufacturers that a permanent service organization is either maintained by each manufacturer or is trained and franchised by the equipment manufacturer, which will be able to render satisfactory service to the equipment on a regular and emergency basis. Provide the name

and telephone number of the person to contact for services.

1.5 QUALITY ASSURANCE

The Contractor shall provide the service of a qualified engineer or technician for start-up, testing, and installation of equipment as specified below. Provide the services of technician or engineer until the installation of equipment is coordinated and completed with checkout. The Contracting Officer reserves the right to reject the engineer or technician proposed if the engineer or technician's qualifications are not suitable or are questionable. More than one engineer or technician may be provided based on the types of specific equipment. One engineer or technician as appointed by the Contractor shall supervise and be responsible for the overall installation, start-up, and testing and checkout of systems.

1.5.1 Report of Prior Installations

Boilers, burners, combustion controls, and feedwater equipment shall be of proven design. Submit evidence to show that substantially identical equipment of comparable capacity within 20 percent has been successfully installed and operated in not less than three installations under comparable operating conditions for a period of not less than 2 years.

1.5.2 Engineer's Qualification Resume

Submit a printed certified qualification resume of the engineer or technician to the Contracting Officer. The engineer or technician's resume shall list applicable experience related to installation, start-up and testing of equipment and applicable factory training and education. Qualifications require the engineer to have supervised two installations of similar size and type which are operating satisfactorily. More than one engineer or technician may be provided based on the types of specific equipment. In event more than one engineer or technician is provided, provide a certified resume for each one and indicate his specific specialty and item of work on the resume.

1.5.3 Start-Up, Testing, and Installation Engineer

The Contractor shall provide the services of a qualified engineer or technician for start-up, testing, and installation of equipment as specified under paragraph QUALIFICATIONS OF ENGINEER. The engineer or technician shall be an employee of the equipment manufacturer.

1.5.4 Installation

Provide an installation engineer or technician to install and supervise the installation of steam boiler system including instrumentation and boiler controls. Provide the technician or engineer until equipment installation is coordinated and completed with checkout.

1.5.5 Start-Up Plan

Submit a written schedule with dates of start-up, test, installation and checkout of equipment to the Contracting Officer.

1.5.6 Start-Up and Test

The specific equipment tested shall be the boiler, boiler controls, boiler

instrumentation and feedwater equipment. The start-up and testing engineer or technician shall remain on the job until the unit has been successfully operated for [_____] days and the unit has been accepted by the Contracting Officer.

1.5.7 Start-Up Certification

After installation of equipment, submit a certificate or certified written statement, signed by the engineer or technician, that the equipment is installed in accordance with the manufacturer's recommendations.

PART 2 PRODUCTS

2.1 BOILERS

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NOTE: Steam-atomizing burners should be specified only if the boiler operating pressure exceeds 690 kPa (gage) 100 psig.
****

****
NOTE: Oil burners can have turndown ratio of 4,5, or 6 to 1.
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NOTE: Repetitive self checking circuits are required only on boilers with modulating controls which operate for long periods of time without burner shutdown.
****

****
NOTE: Steam operated feedwater injectors should be specified only for boilers operating at or above 345 kPa (gage) 50 psig.
****

****
NOTE: Combustion units should have metering combustion controls. Investigate energy savings. Combustion units larger than 7034 kW 24,000,000 Btu/hr input should have oxygen trim in order to optimize fuel usage. CO trim should be considered for larger boiler installations as an adjunct to oxygen trim for increased efficiency.
****

Provide boilers that conform to FS F-B-2902 and have a gross output capacity of at least [_____] kW Btu per hour when operating at a steam pressure of [_____] kPa (gage) pounds per square inch gage (psig) at the site under design conditions when the burner is firing No. [_____] oil conforming to [ASTM D396] having a higher heating value of [_____] MJ/kg Btu per gallon [or] [[natural] [manufactured] [mixed] [liquified petroleum] gas having a higher heating value of [_____] MJ/kg Btu per cubic foot and a pressure of [_____] kPa (gage) psig at the fuel train connection]. Provide [air-atomizing] [or] [steam atomizing] burners. Rotary type burners are unacceptable. Provide burners capable of

operating at a turn down ratio of [_____]. Provide automatic [recycling] [nonrecycling] programming controls and incorporate means for automatic self-checking of the circuit beginning of each start-up cycle. [Include a repetitive self-checking circuit to check all components at not more than the specified time interval in FS F-B-2910 during the entire period of burner operation, and sensor shall be of the ultraviolet type.] [Connections shall be provided for remote starting or stopping of the boilers.] [Provide steam operated feedwater injectors.] Provide combustion control system of the [modulating positioning type where the final control elements for fuel and air inputs, between minimum and maximum limits, are positioned in proportion to load] [semi-metering type where the final control element for one input, either fuel or air, is positioned in proportion to load; flow of the other input is measured and controlled in proportion to load as indicated by the position of the control element for the first input] [full metering (fuel flow/air flow basis) type where the final control element for one input, either fuel or air, is positioned in proportion to load, or the flow for that input is controlled in proportion to load, and the other input is measured and controlled in proportion to the measured flow of the first input] [Provide with oxygen compensation where one of the control elements is biased, modified slightly, on the basis of continuous flue gas analyses, to maintain the proper percentage of oxygen for various firing rates.] Boilers shall be designed in accordance with the applicable provisions of ASME BPVC SEC I and current addenda therein. Boilers shall be equipped with combustion control safety devices conforming to NFPA 85. The following design requirements and conditions shall apply:

a. Maximum allowable steam working pressure of [_____] kPa (gage) psig, as designated by the symbol "P" in the ASME Code and determined by employing the allowable stress values, design rules, and dimensions therein.

b. Operating pressure of [_____] kPa (gage) psig at the steam drum outlet.

c. Feedwater temperature of [_____] degrees C degrees F at entrance to the boiler plant.

d. Elevation of [_____] meter feet above sea level at the site.

e. Ambient air temperatures outside the plant of [_____] degrees C degrees F minimum to [_____] degrees C degrees Fmaximum; average inside temperature of [_____] degrees C degrees F and relative humidity of [_____] percent.

f. Steam quality of [99.5] [99.0] [_____] percent.

[g. Make-up feedwater analysis of [_____] parts per million (ppm) total solids and [_____] ppm total alkalinity.

][h. Steam temperature of [_____] degrees C degrees F at the steam drum outlet.

]2.1.1 Boiler Connections

Requirements for interconnecting piping, insulation, fuel supply, [vibration isolation] [_____] and other related work necessary to provide a complete and operable steam system, whether or not specifically mentioned above, shall conform to applicable requirements of other sections of Division 15, and electrical work shall conform to applicable

requirements in Division 16.

2.1.2 Boiler Efficiency

[Gas fired boilers shall have a steady state combustion efficiency of at least 80 percent.] [Oil fired boilers shall have a steady state combustion efficiency of at least 81 percent.] Boiler efficiency, when tested as specified herein, shall be not less than [79-83] [percent when firing No. [_____] fuel oil] [and] [78-82] [percent when firing [_____] gas]. Obtain efficiency at all loads in a range from the lower limit of the turndown ratio to 100 percent.

2.1.3 Furnace Heat Input

When boiler is operating at maximum rated output, heat input to furnace shall not exceed limits specified in FS F-B-2902 both for input per cubic meter foot of furnace volume and input per square meter foot of effective radiant heating surface.

2.1.4 Steam Quality

The steam releasing surface, drum internals, and steam passages out of the drum shall be such that, with load swings from [50] [75] to 100 percent of the rated capacity per [1] [3] minute period at a boiler feedwater solids concentration of [3500 ppm] [[_____] ppm], the carryover shall not exceed [[_____] ppm] at the boiler nozzle, and moisture in the steam shall not exceed [0.5] [1.0] percent.

2.1.5 Noise Levels

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NOTE: The value for decibels for boiler shall be that required for operating personnel and OSHA requirements taking into consideration room design and other requirements.

****

Conduct noise measurements and exposure analysis under the overall supervision of an industrial hygienist or suitably qualified medical officer from the Navy Regional Medical Center (NRMC). Safety personnel, engineers and others who have been certified by the Chief, Bureau of Medicine and Surgery (BUMED) also may supervise the work. Maintain exposure limits for potentially hazardous noise levels of 85 dB, continuous or intermittent and 140 dB peak sound pressure, impulse or impact. Sound level meter shall conform as a minimum to the Type 2 requirements cited in ASA S1.4.

2.1.6 Air Pollution Control

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Note: Research local, state, and federal emission standards and place any unusual or new requirements in this specification section.

****

Provide fuel burning equipment, combustion control system(s) [and] stack(s) [and emission control equipment] designed, installed, and when applicable, adjusted so that emissions at any loading within the range of the boiler output specified do not exceed federal, state, and local

environmental rules and regulations. Emission requirements to be considered include sulfur oxides, carbon monoxide, particulate, or nitrogen oxides. In addition, the density of any emission to the atmosphere, except during start-up, cleaning of fires, or soot blowing, shall not exceed [No. 1] [No. 2] on the Ringlemann Scale or the Smoke Inspection Guide. The plant shall otherwise conform to applicable Federal, State and Local regulatory requirements. Air quality board "Permit to construct" [will be provided by the contracting officer][will be obtained by the contractor].

2.2 BOILER CONSTRUCTION

2.2.1 General

Provide boilers constructed for specified design conditions and performance requirements in accordance with applicable provisions of ASME BPVC SEC I, and current addenda thereto, and FS F-B-2902. Mount [the] [each] boiler on an internal structural steel base frame of welded construction designed to serve as skids in shipment and to permanently support the unit off the prepared foundation at the site. Assemble and install tubes, drums, and headers in a manner to permit the boiler(s) to be drained dry by gravity. [Show location of the flue gas outlet on drawings.]

2.2.2 Drums

Drums shall conform to FS F-B-2902 and requirements herein. Provide sufficient drum-internals to preclude thermal shock, ensure steam quality as specified herein, Ensure drum capacity addresses expected load swings to insure maintenance of drum level within set points during high load swings, and to properly condition the water in accordance with chemical feed and blowdown systems specified [indicated] [and] [specified]. Nuts, bolts, and other hardware used in assembling steam separators shall be stainless steel. Where drum internals interfere with inspection of part of the boiler drum, make provisions for the easy removal and replacement of whatever internals must be removed in order to effect a complete internal drum inspection and to provide access to tubes. Construct lower drums to preclude build-up of suspended solids, and to permit the complete drainage.

2.2.3 Tubes

Boiler and furnace tubes shall meet the applicable requirements of FS F-B-2902. Tangent tubes or tubes with welded flat studs or a combination thereof shall be provided for water cooling of the furnace rear wall, side walls, roof, and floor. Maximum tube spacing for tubes with welded flat studs should be given so that the problem of studs driving through tube sidewalls due to expansion and contraction does not occur. Burner wall shall be refractory-covered with optional tubes for water cooling. Tubes shall enter the steam drum below the normal water line.

2.3 BOILER TRIM

Boiler trim, including steam stop valves, feedwater stop and check valves, blowoff valves, water level indicators, water columns, pressure gages, safety valves and associated piping, and fittings located within the jurisdictional limits of the ASME Code shall conform to and be installed in accordance with the Code and shall meet supplemental requirements

specified herein. Material selection and pressure ratings for valves and piping shall be in accordance with applicable ANSI standards cited in the ASME Code and shall be based on the maximum allowable boiler working pressure specified herein except as otherwise permitted by the ASME Code.

2.4 BOILER INSTRUMENTATION

In addition to the instruments required by the boiler specification referenced above, provide the following instruments:

a. Temperature gages to indicate temperature of [preheated oil] [air preheater inlet and outlet air][steam temperature].

b. Meters for indicating air flow, drum level and indicating, recording, and totalizing steam and fuel flow. Installation and calibration of these meters shall confirm to ASME PTC 19.5.

c. Instruments to indicate and record flue gas temperature.

d. A draft gage, diaphragm or bellows type, conforming to ASME B40.100. Circular scale with graduations in Pa inches of water. Numerals shall be suitable for reading by persons with normal vision from a distance of 6 meters 20 feet. Select range for intended service and contain completely within the calibrated range. Encompassing no more than 80 percent of the total range. Gages shall be designed and constructed to ensure accuracy within plus or minus 2 percent of the full scale reading in ambient temperatures varying from 2 degrees C to 57 degrees C 35 degrees F to 135 degrees F. Operating mechanisms shall withstand, without affecting gage accuracy or damage to the instrument, surges equal to 100 percent above or below the entire scale range. Gages shall be calibrated prior to installation and shall require no further calibration or adjustment other than setting the pointer to zero. Provide gages with a single pressure connection to the diaphragm, or bellows. Provide pressure connections with a 3-way stopcock which will permit checking of the zero setting and calibration at any time without breaking service connections.

****

NOTE: Select the applicable paragraph(s) from the following

****

[e. A carbon dioxide recorder which shall measure, record, and indicate the percentage by volume of carbon dioxide (CO_2) detected in the flue gas. The recording unit shall be flush mounted and furnished with locking device and master key.

][e. Provide complete oxygen analyzer system to measure oxygen content of flue gases generated by combustion of [gas] [or] [oil] as specified in paragraph BOILER PLANT CONTROLS AND INSTRUMENTS herein for each boiler. The output of the analyzer shall range from zero to 25 percent oxygen. The analyzer shall include the following:

(1) Provide complete aspirating system with proper connection to stack, necessary steam or water aspirating facilities, and piping of proper specification to analyzer. Provide piping in accordance with the oxygen analyzer manufacturer's recommendations and install tight. Install equipment install in accordance with manufacturer's instructions.

(2) Provide a paramagnetic analyzer. Analyzer shall provide oxygen analysis in the zero to 25 percent oxygen range, and have means of calibration. Provide zero range and span adjustments as required.

(3) Analyzer output and recorder input shall be compatible. Provide necessary transducers, connect, and place in proper operation. Follow special instructions relating to electrical transmission between analyzer and recorder as to the application of shielded wiring in conduit.

(4) Check system with two calibrating gases as follows: (a) 100 percent nitrogen, and (b) 3.5 percent oxygen and remainder nitrogen.

][e. Direct Probe In Situ Type: Oxygen analyzer shall be the direct probe type utilizing an in-situ zirconium sensing element. Determine flow characteristic and insert element in location where flue gas is in transition and is representative. Sensing element shall be contained within a protective shield mounted to the ductwork by means of an adapter plate, all furnished by the manufacturer. Analyzer shall be equipped with a facility to allow daily automatic calibration check without removing the analyzer from the process. That is, sample gases may be injected directly on the sensing element while the analyzer is in the process. In order to eliminate temperature effect of flue gases, maintain the cell temperature in the probe at 843 degrees C 1,550 degrees F by means of an externally mounted temperature controller equipped with cold junction compensation and coupled to the probe with at least 6 meters 20 feet of flexible cable. Analyzer shall be FM APP GUIDE approved and certified for "in-stack" analysis technique. Output signal range shall be 4 to 20 milliamps and shall represent 0.25 percent to 25 percent oxygen as a logarithmic function, 0.1 percent to 10 percent oxygen as a logarithmic function, or zero percent to 10 percent as a linear function. [Circular chart recorder shall consist of a two-pen recording control mechanism having 110 volt a.c. electric motor drive. Chart shall be 300 mm 12 inch diameter and rotate once every 24 hours. Output control signal will be 20 to 103 kPa (gage) 3 to 15 psig pneumatic. Sufficient blank charts and four ink cartridges per pen for 400 days operation shall be provided. Recorder shall have a dual 30 degrees strip indicator. Strip indicator and chart paper scale shall be logarithmic or linear and consistent with the analyzer signal conditioning.] [Strip chart recorder shall consist of a two pen solid state electronic recording/controlling mechanism. Strip chart shall be 100 mm 4 inches wide and shall be driven at a speed of 19 mm per hour 3/4 inch per hour. Recording/controlling will operate on 110 volt ac power. Recorder shall be furnished with twelve usable 24 hour logarithmic or linear charts consistent with the analyzer signal conditioning. Inking system shall be a breakaway inking system with replaceable fiber tip pens and 12 ink cartridges. Strip chart recorder/controller shall have vertical scale and horizontal driven chart. Output control signal will be 4 to 20 milliamps dc.] Flue gas temperature scale shall be 149 to 427 degrees C 300 to 800 degrees F. Entire system response shall be not more than 3 seconds.

] f. A smoke density [indicator] [recorder] of the [density limit] [continuous density] type with a scale calibrated in Ringlemann units. Indicating and recording systems shall include circuits for the audible warning of the maximum smoke density-limit. A vibrating

electric horn shall be supplied to sound the audible signal. Otherwise the smoke density [indicator] [recorder] shall conform to CID A-A-50566.

[g. The annunciator shall be of the solid state type and shall annunciate safety interlock and limit switch shut-downs, including flame failure, high and low water, high steam pressure, [high gas pressure,] [low gas pressure,] [high oil pressure,] [low oil pressure,] [low atomizing steam pressure,] [draft fan failure,] [high and low temperature,] [and] [_____]. Annunciator shall include at least [two] [_____] spare points and audible alarms for at least high and low water conditions. Annunciator shall not require special or additional devices which could affect the sensitivity of the boiler limit switches. Annunciator shall provide means to indicate the first limit or off-limit condition causing burner shutdown and to sound an alarm. Annunciator shall have a test button and a feature capability to store information on additional causes of burner shutdown. Subsequent causes of burner shutdown will be indicated after the operator acknowledges the first burner shutdown. A dust tight enclosure shall be provided.

]2.4.1 Instrumentation

[Instrumentation, such as the steam flow recorder, steam flow totalizer, air flow recorder, [carbon dioxide] [oxygen] recorder, and flue gas temperature recorder may be combined into one or more meters having multiple pens plus integrating capabilities as required for specified totalization functions.] [Instrumentation for recording and integrating steam flow, for recording percent of CO_2 or O_2 in the flue gas, and for recording flue gas temperature shall be combined in a single boiler operation meter having three pens using different colored ink.]

2.4.2 Control Panel

The boiler control panel shall include the following switches, controls, and accessories:

a. Boiler on-off pushbutton station with indicating lights.

b. Draft fan manual, start-stop, pushbutton station with indicating lights for on, off, and tripped.

c. Controllers for the combustion control system.

d. Manual-automatic stations for individual controllers of the combustion control system.

e. [Indicating lights and alarm with silencer switch to signal nonrecycling safety shutdowns as specified herein [and excess smoke density conditions].] [Annunciator.]

f. Manual switch to transfer combustion burner and controls from oil to gas and vice versa.

g. Switch and indicating lights to control emergency gas shut-off valve.

h. [Electric clock, 300 mm 12 inch dial, with second sweep hand and seal-in driving unit] [Digital clock that indicates hour, minutes, and seconds, with numerals suitable for reading by persons with normal

vision from a distance of 6 meters 20 feet].

2.4.3 Control Systems

The flame safeguard and programming control systems shall be mounted in the central control panel or an auxiliary control panel located adjacent to the main panel adjacent to the boiler. Auxiliary panels, if provided, shall be fabricated as specified herein for the main control panel.

2.5 BOILER PLANT CONTROLS AND INSTRUMENTS

Provide the following plant [controls and] instruments:

a. Instruments to indicate and record feedwater temperature and steam pressure in the deaerator.

b. Pressure gages to indicate steam pressure in main header, conforming to ASME B40.100 [gas pressure in main supply line] [oil pressure] [atomizing steam pressure].

c. A flue gas analyzer, Orsat type, conforming to CID A-A-50504. The analyzer shall determine the CO2, CO, O2 in the flue gas and shall be complete with chemicals and accessories for use in such determinations.

d. A steam flow recorder which shall remotely indicate, record, and totalize the steam flow per hour through the steam header. Provide panel-mounted indicating recorder with a tamper-proof case.

****

NOTE: Insert section numbers for oil and/or gas piping systems in the blanks below.

****

e. Volumetric fuel flow meters in accordance with [_____], [and] [_____].

****

NOTE: Master combustion controller should be used only for automatic recycling boilers.

****

f. A common boiler master combustion controller located on the free standing instrument and control panel to control all boilers with each individual boiler controller acting as a submaster controller. The boiler master control system shall provide for base loading one [or more] boilers. Base loaded boilers shall be selected manually by an externally accessible switch. On call for heat, lead boiler shall cut in and moderate firing rate to satisfy demands. When maximum desired firing rate is reached, lag boiler or boilers shall cut in. Only one boiler shall be on modulating firing at one time. Maximum desired firing rate for base loaded boiler shall be adjusted initially for boiler peak efficiency and shall be capable of easy manual adjustment by operating engineer. Adequate indicators shall be provided to show the method of loading of each boiler, and load being carried by it. Make adjustments at the front panel and no linkage adjustment shall be necessary.

g. The combustion control system shall be capable of maintaining the plant steam pressure at the main header within the tolerance limits of [_____] percent expressed as a percent of the set point values. The

specified tolerance shall apply to any load which, within a one minute period, swings from a steady-state condition to an increase (or decrease) in load equal to a maximum of 10 percent of the plant. Regulation tolerances shall apply to any steady state condition within the plant turndown ratio of [_____]. After a load swing of 10 percent the concentration of oxygen in the flue gas shall not vary more than plus or minus [_____] percent of the values established at time of system set up within a time period of 30 seconds for firing rates of or above 33 percent of maximum, and plus or minus [_____] for firing rates below 33 percent of maximum. [For oxygen compensation, a continuous analysis of flue gases leaving the boiler shall be made and recorded by an oxygen indicator and recorder mounted on the control panel. From this analysis, a signal shall be sent to the fuel-air ratio system which shall be biased in response to the signal to maintain the oxygen levels within plus or minus [10] [_____] percent of the original setting for excess combustion air]. Combustion efficiency shall not be less than that specified in the boiler specification.

2.6 BOILER CONTROL AND INSTRUMENT CABINET(S)

Provide boiler control and instrument cabinet(s) as specified in FS F-B-2902, and may be mounted either on the boiler front or adjacent thereto. The arrangement may also consist of a boiler mounted cabinet containing controls normally provided by the manufacturer and a supplementary cabinet containing controls normally provided by the manufacturer and a supplementary cabinet containing additional controls and instruments required herein. [[Plant master combustion control] [and] [steam flow recorder] shall be mounted on or be adjacent to control panel for number [_____] boiler.]

2.7 FREE-STANDING MULTI-BOILER PLANT CONTROL AND INSTRUMENT PANEL

Provide a free-standing panel and locate as indicated. The panel shall contain all multi-boiler controls, monitoring systems, and panel mounted instruments specified herein and in the reference specifications, except that flame safeguard systems may remain separately mounted in a cabinet at each boiler.

2.7.1 Control Panel Construction

Control panel shall be constructed of not less than 11 gage (3 mm) (0.1196 inch) reinforced steel for face, top, and sides. The enclosed panel shall be not less than 610 mm 24 inches in depth with inside rigidly welded braces. Control panel shall be designed so that all indicating and recording devices and manually operated switches shall be flush mounted in a gasketed removable top front panel with indicating and recording devices at eye-level. A similar removable top rear panel located opposite front panel shall be provided to facilitate wiring, piping, and maintenance. Other operating controls shall be installed on a sub-panel within the enclosure. Access to panel enclosure shall be through gasketed, double piano-hinged doors of not less than 16 gage (1.52 mm) (0.0598 inch) steel. Reinforced doors to prevent sagging and provided with a 3 point compression type fastener and polished key lock handle. A full width fluorescent lighting canopy shall be prime coated and finished in baked enamel. Identify flush mounted devices with engraved lamicore nameplates. Adequately reinforce, suitably skirt, and suitably design panel base to permit anchoring to the floor or foundation.

2.7.2 Control Panel Wiring and Piping

Control panel shall be factory pre-wired in accordance with NFPA 70. Wire shall be thermoplastic Type THW, THWN, XHHW, or UL approved for the intended use, color or number coded, and run in plastic ducts to numbered terminal blocks. Control circuits shall be separately fused with properly rated cartridge type fuses. Power leads to and from magnetic starters and contactors shall terminate at terminal blocks so that no field wiring in control compartment is necessary except from terminal blocks to external equipment. Control leads to and from external control devices shall terminate at separate terminal blocks from power leads. Steam, draft, and air operated devices shall be factory piped to permanently affixed external connections. Pneumatic signals shall be either 20 to 103 kPa (gage) 3 to 15 psig or 20 to 207 kPa (gage) 3 to 30 psig. Piping connections to indicators shall be copper tubing conforming to ASTM B88M ASTM B88. The boiler operating switch shall have a dust-tight sealed snap-action type. The precision switches shall have cadmium, silver, or platinum contacts, wiping action type, rated at 10 amperes. Electrically or pneumatically test controls and equipment to simulate complete operational sequence.

2.8 BREECHING

Connect breeching to [the] [each] boiler and to intermediate heat recovery equipment as required. Structural materials shall comply with the applicable sections of the AISC 360, "Structural Steel Buildings Allowable Stress Design and Plastic Design." Shop connections shall be welded gas-tight. Field connections may be welded or bolted as required for joining breeching to equipment. Hot dipped galvanized bolts and lock washers shall be supplied for all bolted connections, shall not be less than 10 mm 3/8 inch diameter and spaced not more than 76 mm 3 inches apart. Furnish bolted joints with 3.20 mm 1/8 inchthick non-asbestos gaskets. Breeching plate shall be not less than 10 gage (3.40 mm) (0.1345 inch) in thickness. Welding shall conform to AWS Z49.1 and AWS D1.1/D1.1M. Breeching system shall provide for maximum expansion and contraction. Expansion joints shall be of the guided, flexible-crease type with flexible element of not less than 16 gage (1.50 mm) (0.0598 inch) thick stainless steel. Provide access doors constructed of cast iron or reinforced steel plate with gaskets and positive closing latches of sufficient number to ensure a gas-tight seal. Clean breeching of rust and scale after fabrication. Insulation and covering for breeching shall be as specified in [Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS].

2.8.1 Round Breeching

Construct round breeching 305 mm 12 inches in diameter and smaller of not less than No. 10 gage (3.40 mm) (0.1345 inch) steel with longitudinal groove type seam. Joints between lengths of breeching shall be of the tight slip fit type with not less than 100 mm 4 inchengagement. Construct round breeching over 305 mm 12 inches in diameter of not less than No. 10 gage (3.40 mm) (0.1345 inch) steel with welded seams and joints. Construct round breeching over 457 mm 18 inches in diameter of not less than No. 10 gage (3.40 mm) (0.1345 inch) tank steel with seams and joints welded.

2.8.2 Expansion Joints

2.8.2.1 Metallic Breeching Expansion Joints

Provide factory fabricated metallic breeching expansion joints [where indicated]. Expansion joints shall be guided metal bellows type capable of a minimum of [_____] mm inches of axial travel. Form metal bellows from not less than 1.60 mm 1/16 inch thick type 321 stainless steel plate. Cover plates shall be not less than 3.20 mm 1/8 inch thick steel plate.

2.8.2.2 Non-Metallic Expansion Joints

Provide factory fabricated non-metallic breeching expansion joints 3.20 mm 1/8 inch minimum thickness [where indicated]. Expansion joints shall be constructed of a fluoroelastomer vulcanized to two plies of knitted wire mesh capable of a minimum of [_____] mm inches of axial compression, [_____] mm inches of axial extension and [_____] mm inches of lateral offset [unless indicated otherwise]. Joints shall have a continuous operating temperature rating of 204 degrees C 400 degrees F, with excursion design standards up to 400 degrees C 750 degrees F. Operating pressure range shall be minus 34 kPa (gage) 5 psig to plus 34 kPa (gage) 5 psig. Expansion joints shall be preformed with integrally molded corners, suitable for mounting against a 150 mm 6 inch flange. [Provide carbon steel backup bars with slotted holes, bolts, and nuts.]

2.8.3 Breeching Hangers

Design breeching hangers to carry not less than 5 times the breeching weight. Hangers for round breeching shall be of the band type, with hanger rods. Hangers for rectangular breeching shall be of the trapeze type, with angle support member and hanger rods. Make all hangers of steel.

2.8.4 Cleanout Doors

Secure cleanout doors to the ends and sides of the breeching where indicated or where required to effectively clean the breeching. Construct cleanout doors of a gage steel not less than that of the breeching and secure to a 32 by 32 mm 1 1/4 by 1 1/4 inch angle frame and spaced not over 152 mm 6 inches on center; provide 1.60 mm 1/16 inch thick fiber non-asbestos gasket between cleanout doors and frames. Doors shall be squared and shall be full height of diameter or side of breeching up to a size of 610 mm 24 inches maximum, except for cleanout doors less than 305 mm 12 inches in height shall be rectangular and shall be 305 mm 12 inches in length. Plug type cleanouts are not acceptable. Provide additional cleanout doors where needed.

2.9 BOILER STACKS

Provide [One] [_____] [refractory-lined], [dual wall insulated], steel stack(s), [each] [_____] mm inches in diameter inside [refractory] by [_____] meter feet overall length, and install where indicated.

2.9.1 Construction

[The] [Each] stack may be factory or field assembled. [The] [Each] stack shall be [prefabricated double or triple walled] [fabricated] of 6.40 mm 1/4 inch structural steel plates in accordance with ASTM A283/A283M.

Stack sections shall be of welded construction and fabricated in sections not greater than 6 meters 20 feet nor less than 1.50 meters 5 feet in length. Longitudinal seams shall have continuous butt welded joints. The section or horizontal joints of [refractory lined] stacks shall be flanged with angles welded to the shell, and sections bolted together. Angles shall be not less than 50 mm by 50 mm by 6.40 mm 2 inches by 2 inches by 1/4 inch. [The refractory joint shall be "buttered" with a high temperature air setting bonding refractory before each section is assembled.] Stacks shall be set on a 13 mm 1/2 inch thick steel base plate having a diameter 50 mm 2 inches larger than the outside diameter of the base angle. Base angles and anchor shall be a minimum of 10 mm 3/8 inch thick and 13 mm 1/2 inch diameter. A reinforced concrete foundation shall be provided. Concrete for foundation and reinforcing shall be as detailed on drawings and as specified under the concrete section of this specification. Provide stacks with steel guide shoes and bearing plates on all four sides at the roof level. Guides and bearing plates shall be structural shapes not less than 6.40 mm 1/4 inch thick. Guides shall be not less than 305 mm 12 inches long and shall be welded to the stacks. Bearing member shall be fastened with steel stud anchors welded to the bearing member. Provided a clearance of 3.20 mm 1/8 inch between guide and bearing member for stack diameter expansion after stacks are in normal operation. Provide flashing and counter-flashing around [the] [each] stack as detailed on drawings.

2.9.2 Breeching Connection

Provide a breeching connection of the same thickness as the stack and weld to [the] [each] stack and reinforce the stack externally with steel plates and/or structural members as required to compensate the stack for the structural strength of the metal removed. Provide a flange for bolting breeching to this connection. Provide a hinged cast-iron or steel cleanout door with a heavy duty cast steel frame at the bottom of each stack. Frame and door shall be fitted gas-tight. Doors shall be a minimum of 457 by 610 mm 18 by 24 inches in size.

2.9.3 Lining

Stack lining shall be an alumina-silica-base castable insulating refractory of the hydraulic setting type certified by the manufacturer to be suitable for the specific application, considering the flue gas temperature, velocities, moisture content, and corrosive qualities of the fuel being burned, applied to each stack under the direct supervision of a qualified representative of the manufacturer. The lining thickness shall be 76 mm 3 inches. Stack base plate exposed inside of each stack shall be covered with castable insulating refractory as specified for stack lining. Boiler stack lining shall have a minimum pyrometric cone equivalent (PCE) of 10 1304 degrees C 2380 degrees F with a maximum installed dry weight of 720 kilogram per cubic meter 45 pounds per cubic foot and a recommended service temperature of 1093 degrees C 2000 degrees F. The top 3 meters 10 feet of lining shall be a dense castable refractory 1840 kilograms per cubic meter 115 lb/ft 3 suitable for all weather and flue gas temperature conditions encountered in the top of stacks. Stack lining shall be fastened to each stack with heat and corrosion resistant alloy metal anchors which maintain their structural strength up to 760 degrees C 1400 degrees F. Anchor clips shall be spaced vertically not greater than 610 mm 24 inches on centers and closer horizontally as required by diameter of the stack. Types, size, and number per section shall be randomly located by the stack and refractory manufacturer to adequately support refractory lining to permit expansion and prevent cracking of refractory. A 50 mm 2

inch mesh galvanized wire screen of 8 gage (4.10 mm) (0.1620 inch) wire shall be attached to the clips for reinforcing the refractory. Locate screen at midpoint of the refractory thickness and cover end of clips with at least 25 mm one inch of refractory.

2.9.4 Stacks

Clean stacks of dirt, rust, oil, and grease by wire brushing and solvent degreasing and given one shop coat of heat-resisting aluminum paint conforming to FS TT-P-28 on the inside and outside. The coat of paint shall have a minimum dry film thickness of 0.025 mm one mil.

2.10 BLOWDOWN EQUIPMENT

Furnish [the boiler] [the plant] with equipment, tanks, and controls necessary for bottom [and continuous] blowdown of the boiler(s). The equipment for bottom blowdown systems shall include a [blowdown tank] [and sample cooler]. [Continuous blowdown systems shall be of the packaged, proportional type consisting of a heat exchanger, flow control valve, surge tank, [and] sample cooler, [and blowdown control console with test sink]]. Install and pipe blowdown equipment as indicated and it shall conform to the recommendations of the NBBI NB-27.

2.10.1 Bottom Blowdown Tank

The blowdown tank shall be fabricated of welded steel plate in accordance with ASME BPVC SEC VIII D1. The tank shall be a vertical cylindrical tank designed for the working pressure of the boilers. The tank shall be equipped with a tangential blowdown inlet located so as to impinge on a 10 mm 3/8 inch carbon steel wear plate extending at least 180 degrees around the interior circumference of the tank from the point of inlet. The tank shall be equipped with an internal overflow, vent, drain, safety relief valve, and gage glass with try cocks, blowdown cock, and guard. The interior of the tank shall be protected by an epoxy coating system suitable for continuous water immersion and operation at a minimum temperature of [121] [149] degrees C [250] [300] degrees F. When buried, the tank [shall be fitted [with renewable magnesium anodes] [with cathodic protection equipment] to minimize galvanic corrosion.] [shall be constructed of Class A reinforced concrete and shall be fitted with a bolted steel manhole frame and cover. Install the blowoff pipe, vent pipe, and drain pipe in pipe sleeves built into the concrete. Fill and caulk the space between the pipe and sleeves with lead wool or equivalent to make a watertight seal. The tank shall be divided into two sections by means of a baffle to form a sediment chamber.] Size and locate the blowoff tank as shown.

2.10.2 Sample Cooler

Provide a water-cooled, shell-and-tube or shell-and-coil type heat exchanger designed for cooling sample of boiler water prior to chemical testing. The sample cooler shall be furnished as a component of the packaged continuous blowdown system when such a system is being furnished. The cooler shall consist of a cast iron or steel shell with copper coil or copper alloy tubes and shall be equipped with a brass or bronze sampling cock. [The cooler shall be connected to a header and so valved that a sample can be withdrawn from any boiler as desired.] [Furnish concentrometer kit containing necessary glassware, reagents, and instructions for determining boiler water concentrations.]

2.10.3 Continuous Blowdown System

****

NOTE: Specify continuous blowdown only where makeup water ratio is in excess of 20 percent of the boiler output or where the total dissolved solids of the makeup water are in excess of 500 ppm.

****

****

NOTE: Include this requirement if a console type unit is indicated.

****

Provide a complete packaged unit of the automatic-proportioning, [manual-apportioning] type wherein the amount of blowdown from the [boiler] [plant] is automatically proportioned to the amount of make-up feedwater [and the total amount of blowdown from the plant is manually apportioned between boilers according to their steaming rate]. The system shall include either an automatic-proportioning valve and a heat exchanger, or a concentric tube automatic proportioning control which shall be provided with a separate heat exchanger when necessary to meet the performance requirements indicated or specified herein. The system shall be designed for not less than boiler design pressure and shall be capable of heating the feedwater from [_____] degrees C F to [_____] degrees C F at the flow rates indicated. The heat exchanger shall consist of a steel shell and heads with Type 304 stainless steel tubes arranged in a removable U-bend bundle. The shell shall be constructed and tested in accordance with ASME BPVC SEC VIII D1 for the specified boiler operating pressure. The automatic proportioning valve shall be provided with a sensing orifice on both the make-up and blowdown lines and shall be of the adjustable ratio type in which the ratio of make-up to blowdown may be set anywhere within a range of [30:1] [_____] to [4:1] [_____]. The automatic proportioning control shall consist of two concentric tubes, the inner tube being of a thermostatic design which acts directly against an adjustable seat in response to the temperature differential between the blowdown in the inner tube and the makeup water between the inner and outer tubes. Manual apportioning valves shall have bronze bodies with stainless steel seats and disks and shall be of the indicating type specifically designed for blowoff service. The blowdown system shall be complete with strainers, stop valves, [blowdown meters,] thermometers, and other accessories necessary to form complete packaged units. [The blowdown control console shall include illuminated sight flow indicators, automatic flushing and cooling valves, and complete panelboard instrumentation, as well as a cabinet type laboratory sink with drain board, back splash, hot and cold service water faucets, [air cock,] and electrical outlet.]

2.11 FEEDWATER EQUIPMENT

2.11.1 Boiler Feed Pumps

Boiler feed pumps shall conform to CID A-A-50562 for motor driven, horizontal split case or support head boiler feed pumps, except as otherwise specified herein. Pumps may be of either the centrifugal or peripheral-turbine type with alloy steel casing and shall be bronze or alloy steel fitted. For centrifugal type pumps, by-pass orifice shall be provided, and for turbine type pumps, pressure relief valves shall be provided. Packed stuffing boxes or mechanical seals suitable for [121

degrees C 250 degree F operation] [the design conditions indicated] shall be provided. Pumps shall be designed for the net positive suction head, discharge head, and water temperature indicated. Pump casings should be rated at suction head plus shutoff head at design temperature. [Capacity under the above condition shall be not less than indicated.] [Capacity of each pump under the above conditions shall be not less than the following percentage of maximum total boiler capacity: centrifugal pumps, 125 percent; turbine pumps, 150 percent.] Pump motors shall be [totally enclosed] [dripproof with encapsulated windings].

2.11.2 Boiler Feed Tank

Feed tank and stand construction shall conform to FS F-P-2908 for horizontal cylindrical stand mounted receivers, and shall be [hot dip galvanized or cement lined] [epoxy coated] [[_____] coated]. Tanks shall be provided with vents, gage glass, drain and overflow connections, pressure gage, thermometer, [float operated make-up water feeder] [float switch and make-up water solenoid valve] [and preheater assembly consisting of corrosion resistant steam diffuser tube, steam pressure reducing valve, strainer and thermostatic steam valve]. The boiler feed tank assembly shall include strainer and pump control box. Tank capacity and connection sizes shall be as indicated.

2.11.3 Deaerator

The deaerator shall be of the pressurized type having an ASME stamped pressure vessel and conforming to FS W-H-2904 and requirements specified herein. Deaerating assembly and deaerated water storage may be in the same or separate shells. When external vent condensers are provided, they may be located as recommended by the manufacturer. Provide an ASME certified pressure relief valve sized [as indicated][in accordance with Table II of FS W-H-2904]. Inlet piping and accessories shall be as indicated. Feedwater pumps, as specified herein, interconnecting piping, and control box shall be provided as part of the deaerator package. Deaerator capacity shall be not less than [indicated] [1.25 times that required to supply the boiler(s) at maximum firing rate]. The temperature of the water delivered at maximum capacity shall be equivalent to saturated steam temperature at the operating pressure of the deaerator, which shall be as indicated, and the oxygen content shall not exceed [0.005] [0.003] cubic centimeters per liter as determined by the Referee Method A (Colorimetric Indigo Carmine) of ASTM D888 without O2 scavenging chemical addition. Water storage capacity shall be sufficient to operate the boilers at maximum capacity for [10] [_____] minutes. A power and control panel shall be furnished with the package deaerator unit. The panel enclosure shall be NEMA ICS 6, Type 12 and shall be fabricated and painted in accordance with the manufacturer's standard practice. A separate compartment shall be furnished for each feedwater pump and each shall include a fused disconnect switch with external operating handle and a magnetic starter with three-leg overload protection. The panel shall include signal lights, an audible alarm to signal high and low levels in the deaerator, and required relays, transformers, and manual-automatic switches.

2.11.4 Surge Tank and Transfer System

The condensate storage and surge tank shall be a cylindrical welded steel tank mounted and supported as indicated. Design and construct the tank in accordance with the ASME BPVC for the indicated working pressure. Storage capacity shall be [as indicated] [sufficient to provide adequate water to

the deaerator for [10] [_____] minutes of [boiler] [plant] operation at maximum capacity]. Inlet connections for condensate and make-up water shall be as indicated. Equip the tank with liquid level controllers and valves and alarms as indicated. Equip tank with pressure and temperature gages, water level gage, vent, drain, and overflow. Tank shall be [hot dip galvanized or cement lined] [epoxy coated] [[_____] coated]. The surge tank assembly shall include condensate transfer pumps, interconnecting piping including strainer, and control box as indicated. The transfer pumps, except for head and temperature requirements which shall be as indicated, shall operate continuously with a float controlled flow and shall conform to the requirements for boiler feed pumps specified herein.

2.11.5 Feedwater Treatment Equipment

2.11.5.1 Feedwater Characteristics

****
NOTE: Insert source of water supply.
****

Equipment for the chemical treatment of the boiler make-up feedwater shall be designed to reduce the boiler water concentrations to the limits specified herein when handling raw water having the following impurities reported as milligrams per liter (mg/liter) (formerly parts per million):

a. Total hardness as $CaCO_3$ _____

b. Calcium hardness as $CaCO_3$ _____

c. Magnesium hardness as $CaCO_3$ _____

d. Alkalinity as $CaCO_3$ _____

e. Sodium as Na _____

f. Chlorides as Cl _____

g. Sulfates as SO_4 _____

h. Sulfites as SO_3 _____

i. Phosphate as PO_4 _____

j. Silica as SiO_4 _____

k. Nitrates as NO_3 _____

l. Iron as Fe _____

m. Free carbon dioxide as CO_2 _____

n. Total dissolved solids _____

o. Suspended solids _____

Raw water shall be delivered to the plant [from the water distribution system of the [_____]] [from [_____]] at a normal pressure of [_____] kPa (gage) psig measured at the meter to the plant. See NAVFAC MO 225 for additional guidance.

2.11.5.2 Water Softener

Provide water softener equipment of the type, size, and arrangement indicated. When operating [under the indicated design conditions] [with an inlet water flow of [_____] liter per second gpm] effluent analysis shall be as follows:

a. Total hardness as $CaCO_3$ less than [_____] mg/liter.

[b. pH [_____] to [_____].

c. Total dissolved solids less than [_____] mg/liter.

d. [_____].

]2.11.5.3 Zeolite Water Softener

****
NOTE: The type of equipment used shall be left to the designer and local condition.
****

Conform to WQA S-100 and shall have [automatic] [manual] controls. The softener(s) shall be equipped for [sodium cycle] [hydrogen cycle] [the type of cycle necessary to provide the treated water analysis specified above]. [Each softener tank shall be provided an operating valve to permit the regeneration of one tank while the other is in service.]

2.11.5.4 Lime Soda Softener

****
NOTE: The type of equipment used shall be left to the designer and local condition.
****

Conform to CID A-A-50573 for the type indicated.

2.11.5.5 Salt Regeneration Dealkalizer

****
NOTE: The type of equipment used shall be left to the designer and local conditions.
****

Provide a salt regeneration dealkalizer as indicated.

2.11.5.6 Pressure Filter

Provide [a] pressure filters of the type and arrangement indicated, and with [manual] [automatic] controls. The filter shall conform to CID A-A-59249. Performance shall be specified in CID A-A-59249 with raw water analysis as specified herein, and operating conditions as indicated. Filter shall be equipped to operate properly for not less than 2 days without operator attention to renew or regenerate filter coatings, chemicals, or other filter media.

2.11.5.7 Chemical Feeder

Size and connect the chemical feeder as indicated. Chemical feeder shall be suitable for the flow, pressure, and temperature conditions at the point of connections. Provide chemical feed storage as indicated. [The feeder shall be of the [automatic proportioning type] [shot type] conforming to FS F-F-2901.] [The feeder shall be of metering pump type conforming to CID A-A-50573 for chemical feeders.]

2.11.5.8 Feedwater Test Equipment

Provide for determining boiler water condition which includes an assembly of indicator solutions, standardized solutions and test glassware, with cabinet. The solution types shall permit tests for water hardness, total alkalinity, hydroxide, carbonite alkalinity, and chloride content, in parts per million. Feedwater test equipment shall employ a standardized soap solution for the hardness test, and a dilute sulfuric acid solution with a methyl orange indicator for total alkalinity. Hydroxides and carbonate alkalinity shall be determined with a phenolphthalein indicator, and the chloride content with a silver nitrate solution. Furnish standardized phenolphthalein color slides shall be furnished for accuracy in alkalinity tests.

2.12 ELECTRIC MOTORS

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NOTE: Select standard efficiency for motors used less than 750 hours per year and high efficiency for motors used over 750 hours per year. Packaged boilers should utilize the manufacturer's standard efficiency motor.

****

Motors which are not an integral part of a packaged boiler shall be rated for [standard] [high] efficiency service per Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Motors which are an integral part of the packaged boiler system shall be the highest efficiency available by the manufacturer of the packaged boiler.

PART 3 EXECUTION

3.1 INSTALLATION

Arrange work in a neat and orderly manner so that minimum storage space for equipment and material is required at the project site. Install equipment and material in accordance with the best commercial practices. Systems shall be neat in appearance, compact, workmanlike in construction and assembly, and installed for continuous service. Parts shall be readily accessible for inspection, repair, and renewal. Inspect equipment and material upon delivery and test after installation. Protect material and equipment from the weather. Contractor shall repair any damage to equipment, building or worksite that occurs during the execution of his work. Contractor shall leave worksite in a condition equal to or better than that existing before the work was started.

3.1.1 Equipment Foundations

Locate as shown and construct of sufficient size and weight, and proper design to preclude shifting of equipment under operating conditions, or

under abnormal conditions which could be imposed upon equipment. Foundations shall meet requirements of equipment manufacturer. Maintain equipment vibration within acceptable limits, and shall be suitably damped and isolated. Grout equipment mounted on concrete foundations before installing piping. Install piping in such a manner as not to place a strain on equipment. When foundations submitted by Contractor shop drawings are different from those shown, submit calculations by the equipment supplier.

3.1.2 Welding

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NOTE: Use of the ASME code or the Federal Construction Guide Specification section on welding depends upon the agency's requirements.

****

****

NOTE: Insert appropriate Section number in blank below.

****

Work shall be in accordance with [the applicable sections of the ASME BPVC SEC I] [[_____] WELDING] and AWS Z49.1.

3.1.3 Painting

Equipment shall be factory finished to withstand the intended end use environment in accordance with the specifications for the particular end item. Field paint equipment not factory finished as specified herein. Retouch damaged areas of factory-finished equipment on which finish has been damaged and then give a complete finish coat to restore the finish to its original condition. The finish coat shall be suitable for exposure in the intended end use environment. Spray painting shall comply with OSHA 29 CFR 1910-SUBPART D.

3.1.3.1 Cleaning and Application

Remove dirt, rust, oil, and grease by wire brushing and solvent degreasing prior to application of paint. Apply paint to clean and dry surfaces only. Where more than one coat of paint is specified, apply the second coat after the first coat is thoroughly dry. Retouch damaged painting before applying the succeeding coat. Finished surfaces shall be smooth. The painting of zinc coated and other corrosion-resistant metal surfaces is not required unless otherwise specified herein.

3.1.3.2 Smoke Flues, Boiler Casing, and Draft Ducts

In unfinished areas, paint smoke flues, boiler casing, and black steel draft ducts with heat-resisting aluminum paint, two coats on the inside of flues and ducts and one coat on the outside, each coat to a minimum dry film thickness of 0.025 mm one mil applied directly to clean bare metal surfaces. Paint exposed surfaces of protective metal covering over insulation, including zinc-coated surfaces, with two coats of heat-resisting black paint to a minimum dry film thickness of 0.05 mm two mils applied directly to the clean bare metal surfaces. Do not paint zinc-coated ducts.

3.1.4 Boiler Cleaning

After installation, boil out [the] [each] boiler, under supervision of the manufacturer, with a soda ash or another alkaline cleaning solution to cleanse internal surfaces of oil, grease, mill scale, and dirt. Dispose of the waste products from this process according to the requirements of the applicable federal, state, and local environmental regulations. Following initial cleaning, the boilers should be flushed, drained, washed down (internally and externally) and reinspected to ensure that no traces of oil or foreign matter are present. Next, drain the boiler and associated piping and refill it with treated, softened water. At all times after initial cleaning, the Contractor shall protect the boiler, tanks, and piping against internal corrosion until testing is completed and the boiler[s] [is] [are] accepted. Provide chemicals, labor for introducing chemicals, and professional services for control and supervision of the treatment process.

3.1.5 Marking

Equipment, switches, motor controllers, and other controls or indicating elements not located on the main control panel shall be identified by stencils or printed, stamped, or manufactured signs of rigid plastic or non-ferrous material. Lettering for identification signs shall be not less than [4.80] [_____] mm [3/16] [_____] inch high. The nomenclature and identification symbols used on the signs shall correspond to those used in the maintenance manuals, operating instructions, and schematic diagrams. The signs shall be rigidly affixed to the equipment or devices without impairing functions or, if this is not possible, shall be attached as a tag using a wire or chain. In addition to the identification signs, each major component of equipment shall have a nameplate listing the manufacturer's name, model number, and when applicable, electrical rating and other information required by pertinent standards or codes.

3.2 FIELD QUALITY CONTROL

Performance of tests and inspections as specified herein to demonstrate that boilers and auxiliary equipment, as installed, are in compliance with contract requirements. During boiler system start-up tests, factory-trained engineers or technicians employed by manufacturer of such components as the burner, flame safeguard and combustion controls, feedwater treatment equipment, and other auxiliary equipment shall be present, as required, to ensure the proper functioning, adjustment, and testing of individual components and systems, and to train plant operation personnel in the operation and maintenance of them. No bypassing, use of jumpers, or other disablement of control systems will be allowed unless specified elsewhere. Labor, equipment, fuel, and test apparatus required for testing shall be furnished by the Contractor.

3.2.1 Inspections and Test

Inspections and tests at the site shall be made under the direction of and be subject to the approval of the Contracting Officer. The Contractor shall operate [the] [each] boiler and appurtenances prior to final testing and shall ensure that necessary adjustments have been made. A [24-] [48-] [_____] hour advance written notice shall be submitted to the Contracting Officer indicating the equipment is ready for testing. Provide testing equipment, including gages, thermometers, calorimeter, CO, O2, CO2 test equipment that independently analyzes each gas, thermocouple pyrometers, fuel flow meters, water meters, and other test apparatus and set up and

calibrated prior to the test. Draft, fuel pressure, and steam flow may be measured by permanent gages and meters installed under the contract. [Gas flow may be measured by utility company meters.] Provide an analysis of the fuel being used for tests. Control of noise levels developed by exhaust steam, including muffler, globe, and gate valves, shall be conducted in such a manner as not to create a nuisance or hazard, and shall be subject to the approval of the Contracting Officer. Tests shall include the following, and shall be performed when feasible, in the sequence listed:

a. Strength and tightness tests - Hydro test per NAVFAC MO 324.

b. Standards compliance tests - All environmental compliance test as required by federal, state and local laws.

c. Combustion test

d. Operational tests

e. Capacity and efficiency tests per ASME PTC 4

f. Emission test

g. Tests of auxiliary equipment

h. Feedwater equipment test

3.2.2 Strength and Tightness Tests

Subject [_____] [_____] boilers to the following strength and tightness tests:

3.2.2.1 Hydrostatic Testing

After installation and connection, subject [_____] [_____] boilers to an inspection and hydrostatic test to determine that the boiler and appurtenances have not been damaged in transit or handling. The hydrostatic test shall be in accordance with ASME BPVC SEC I, with the test pressure applied for a period required by the Contracting Officer. This test shall be in addition to the hydrostatic tests performed at the factory. [The hydrostatic test at the site shall be certified by an inspector holding an authorized commission from the National Board of Boiler and Pressure Vessel Inspectors.]

3.2.2.2 Pneumatic Testing

Pneumatically test air casing and ducts exterior to the furnace at the maximum working pressure. Use the soap bubble method to verify tightness. Test gas side of boiler normally operated under pressure for tightness at 1-1/2 times the predicted operating pressure in the furnace at the maximum continuous output. For this test, tightly seal the boiler with suitable means to blank off all openings. Admit air to the boiler until the test pressure is reached and then hold. If in a 10-minute period the pressure drop does not exceed 1245 Pa 5 inches water gage, the casing shall be regarded as tight and accepted. Use air pressure and soap bubble tests or comparative carbon dioxide readings for induced draft boilers.

3.2.2.3 Internal Component Test

Hydrostatically test the part of the preassembled fuel oil system that is furnished integrally with the boiler at one and one-half times the maximum operating pressure. Pneumatically test the part of the preassembled gas system that is furnished integrally with the boiler at operating pressure. Use the soap bubble test method to verify tightness of the gas system.

3.2.3 Combustion Tests

Test the fuel burning and combustion control equipment with [the] [each of the] specified fuels at the minimum limit of the turndown range and at increments of 50, 75, and 100 percent of full rated load [plus [_____] percent overload]. [The combustion control system shall maintain 25 to 35 percent excess air at 20 percent of full rated load, and at 50, 75, and 100 percent of load shall maintain an excess air below 15 percent.] Tests shall be conducted by factory-trained combustion equipment engineers as previously specified. Analyze and graphically present test data to show for [the] [each] boiler at tested loads: rates of steam flow; flue gas temperature; percent excess air; steam quality; and percentages of carbon dioxide, carbon monoxide, and oxygen in the flue gas. Test concentrations of sulfur oxides, particulates, volatiles, and nitrogen oxides in the flue gas to ensure compliance with federal, state, and local environmental requirements. Run tests on each fuel after stack temperatures have stabilized with surroundings. Verify and record conformance to the combustion requirements of this specification. Verify proper operation of instrumentation and gages in the control panel during the test.

3.2.4 Operational Test

Continuously test the boiler(s) continuously under varying load conditions to demonstrate proper operability of the combustion control, flame safeguard control, programming control, and safety interlocks. Conduct this test after the adjustment of the combustion controls has been completed under the combustion test. The operational test shall continue for a period of at least [8] [_____] hours and shall include the following:

3.2.4.1 Sequencing

The boiler shall start, operate, and stop in strict accordance with the specified operational sequence.

3.2.4.2 Flame Safeguard

Verify the operation of the flame safeguard controls by simulated flame and ignition failures. Test burners having intermittent pilots by simulating main flame failure while the pilot is burning. Verify the trial-for-pilot ignition, trial-for-main flame ignition, combustion control reaction, and valve closing times by stop watch.

3.2.4.3 Immunity to Hot Refractory

Operate the burner at high fire until the combustion chamber refractory reaches maximum temperature. The main fuel valve shall then be closed manually. The flame sensing safeguard device shall immediately cause the safety shutoff valves to close within the specified control reaction and valve closing times. This test ensures that the flame sensing device will not send a "false positive" signal from glowing refractory.

3.2.4.4 Pilot Intensity Required

Gradually reduce the fuel supply to the pilot flame to the point where the combustion safeguard begins to drop out (sense "no flame") but holds in until the main fuel valve opens. At this point of reduced pilot fuel supply, the pilot flame shall be capable of safely igniting the main burner. If the main fuel valve can be opened on a pilot flame of insufficient intensity to safely light the main flame, readjustment of the flame sensing device is required.

3.2.4.5 Boiler Limit and Fuel Safety Interlocks

Safety shutdown shall be caused by simulating interlock actuating conditions for high and low temperature, high and low steam pressure, high and low drum level, low feedwater, and fuel safety interlock. Safety shutdowns shall occur in the specified manner.

3.2.4.6 Combustion Controls

Demonstrate the accuracy, range, and smoothness of operation of the combustion controls by varying the steam demand through the entire firing range required by the turndown ratio specified for the burner and in case of automatic recycling burners, by further varying the firing rate to require "on-off" cycling. Control accuracy shall be as specified.

3.2.4.7 Safety Valves

The high-pressure limit switch shall be locked out or otherwise made inoperative, and the boiler safety valves shall be lifted by steam. The relieving capacity, popping pressure, blowdown, and reseating pressure shall be determined by observation and measurement to be in accordance with the ASME BPVC SEC I. The ASME standard symbol will be accepted only as indicating compliance with the design and material requirements of the code.

3.2.5 Capacity and Efficiency Tests

Perform the capacity and efficiency tests after satisfactory completion of all tests previously specified herein and after the boilers have been operating [continuously] for [one] [5] [_____] days with no nuisance shutdowns and without the necessity for frequent or difficult adjustments. The contractor is to continuously man the boiler during the test. Perform these tests on each boiler. Conduct tests using [the] [each of the] specified fuels. Test procedures shall be in accordance with the heat loss method of ASME PTC 4 and shall be reported on the ASME Test Form for Abbreviated Efficiency Test. Tests shall be performed at [25], 50, 75 and 100 percent loads. The duration of the tests shall be sufficient to record necessary data but in no case shall test duration be less than [4] [_____] hours [on each fuel].

3.2.6 Auxiliary Equipment and Accessory Tests

Observe and check blowdown valves, stop valves, try cocks, draft fans, oil heaters, pumps, electric motors, and other accessories and appurtenant equipment during the operational and capacity tests for leakage, malfunctions, defects, noncompliance with referenced standards, or overloading, as applicable.

3.2.7 Feedwater Equipment Tests

Perform test of the feedwater treatment equipment in two steps. One test shall be conducted by the Contractor concurrently with either the combustion test or the capacity and efficiency test. A second test will be performed by the Government during the first period of heavy loading after the plant has been accepted and put in service. Deficiencies revealed during the Government tests will be corrected under the guarantee provisions of the contract. Both the first and second series of tests shall determine compliance with the limits for oxygen content and hardness concentrations of this specification. Equipment for taking samples and the test kit for analyzing the samples shall be supplied by the Contractor and shall revert to the Government when the tests are completed.

3.2.8 Deaerating Feed-Water Heater

Test of deaerating feed-water heater shall demonstrate that the equipment installed shall meet the specified requirements as to performance, capacity, and quality of effluent. During the operating test of the boilers, conduct tests to determine oxygen content in accordance with ASTM D888, Method A. Test with no O2 scavenging chemical addition. Boilers shall be operated at varying loads, up to maximum heater capacity, while oxygen tests are being made.

3.2.9 Water Treatment Equipment

Test of water treatment equipment shall meet the requirements specified as to capacity and quality of effluent. Tests for ion exchange units shall cover at least two complete regenerations and capacity runs. Test for hot process or other precipitation type softeners shall cover a minimum continuous period of 48 hours with samples being taken at 2 hour intervals.

3.2.10 Steam Quality

Test for steam quality and water level stability shall be simultaneous under the operating conditions specified.

3.2.11 Steam Tests

Tests for boilers over 2068 kPa (gage) 300 psig not used for power generation or large turbine drives and without super-heaters, shall be made on steam sampled in accordance with ASTM D1066, and tested for moisture in accordance with the calorimetric method outlined in Section 3, ASME PTC 19.11. Conductivity method may be used in lieu of the calorimetric method, in which case the conductivity of the steam corrected for carbon dioxide and ammonia content shall not exceed 30 microhms/cm at 18 degrees C. The steam for boilers less than 2068 kPa (gage) 300 psig used for power generation or turbine drive for air conditioning equipment or with super-heaters, and for boilers over 2068 kPa (gage) 300 psig, shall be tested in accordance with the conductivity method in ASTM D2186, with the conductivity of the steam corrected for carbon dioxide and ammonia content not to exceed 4.0 microhms/cm at 18 degrees C.

3.2.12 Water Level Stability Test

Test shall first be conducted by use of the manual bypass around the feed-water regulator. Test shall be repeated using the automatic feed-water regulator. To be acceptable, the boiler should maintain specified water level stability under both conditions.

3.3 SCHEDULE

Some metric measurements in this section are based on mathematical conversion of inch-pound measurements, and not on metric measurements commonly agreed on by the manufacturers or other parties. The inch-pound and metric measurements shown are as follows:

Products	Inch-Pound	Metric
a. [_____]	[_____]	[_____]

-- End of Section --