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 30.00 10

HEAT RECOVERY BOILERS

05/20

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USACE / NAVFAC / AFCEC / NASA	**UFGS-23 52 30.00 10 (May 2020)**

Preparing Activity: USACE	**Superseding without Revision UFGS-23 52 43.00 10 (April 2008)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

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SECTION 23 52 30.00 10

HEAT RECOVERY BOILERS
05/20

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NOTE: This guide specification covers the requirements for both fire-tube and water-tube heat recovery, steam generating boilers with individual capacities from 907 to 136,000 kg 2,000 to 300,000 pounds of steam 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).

****

PART 1 GENERAL

1.1 REFERENCES

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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.

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL, INC. (AMCA)

AMCA 99	(2016) Standards Handbook
AMCA 210	(2016) Laboratory Methods of Testing Fans for Aerodynamic Performance Rating

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 9	(2015) Load Ratings and Fatigue Life for Ball Bearings

AMERICAN BOILER MANUFACTURERS ASSOCIATION (ABMA/BOIL)

ABMA Boiler 402	(2012) Boiler Water Quality Requirements and Associated Steam Quality for Industrial/Commercial and Institutional Boilers

AMERICAN PETROLEUM INSTITUTE (API)

API STD 610	(2010; Errata 2011) Centrifugal Pumps for Petroleum, Petrochemical, and Natural Gas Industries

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.1	(2003; R 2018) Unified Inch Screw Threads (UN and UNR Thread Form)
ASME B18.2.1	(2012; Errata 2013) Square and Hex Bolts and Screws (Inch Series)
ASME B18.2.2	(2015) Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)
ASME B31.1	(2020) Power Piping
ASME B40.100	(2013) Pressure Gauges and Gauge Attachments
ASME BPVC SEC I	(2017) BPVC Section I-Rules for Construction of Power Boilers
ASME BPVC SEC IV	(2017) BPVC Section IV-Rules for

	Construction of Heating Boilers
ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1
ASME CSD-1	(2016) Control and Safety Devices for Automatically Fired Boilers
ASME MFC-3M	(2004; Addenda A 2007; R 2017) Measurement of Fluid Flow in Pipes Using Orifice, Nozzle, and Venturi
ASME PTC 4	(2013) Fired Steam Generators
ASME PTC 10	(1997; R 2014) Performance Test Code on Compressors and Exhausters
ASME PTC 12.3	(1997; R 2014) Performance Test Code on Deaerators
ASME PTC 19.2	(2010; R 2015) Pressure Measurement
ASME PTC 19.3 TW	(2016) Thermowells Performance Test Codes
ASME PTC 19.10	(1981) Flue and Exhaust Gas Analyses
ASME PTC 19.11	(2008; R 2013) Steam and Water Sampling, Conditioning, and Analysis in the Power Cycle

AMERICAN WELDING SOCIETY (AWS)

AWS B2.1/B2.1M	(2014; Errata 2015) Specification for Welding Procedure and Performance Qualification

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M	(2019) Standard Specification for Carbon Structural Steel
ASTM A48/A48M	(2003; R 2016) Standard Specification for Gray Iron Castings
ASTM A106/A106M	(2019a) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A123/A123M	(2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A153/A153M	(2016a) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

ASTM A179/A179M	(1990; R 2012) Standard Specification for Seamless Cold-Drawn Low-Carbon Steel Heat-Exchanger and Condenser Tubes
ASTM A192/A192M	(2002; R 2012) Standard Specification for Seamless Carbon Steel Boiler Tubes for High-Pressure Service
ASTM A242/A242M	(2013; R 2018) Standard Specification for High-Strength Low-Alloy Structural Steel
ASTM A249/A249M	(2018a) Standard Specification for Welded Austenitic Steel Boiler, Superheater, Heat-Exchanger, and Condenser Tubes
ASTM A278/A278M	(2001; R 2020) Standard Specification for Gray Iron Castings for Pressure-Containing Parts for Temperatures Up to 650 degrees F (350 degrees C)
ASTM A285/A285M	(2017) Standard Specification for Pressure Vessel Plates, Carbon Steel, Low- and Intermediate-Tensile Strength
ASTM A297/A297M	(2020) Standard Specification for Steel Castings, Iron-Chromium and Iron-Chromium-Nickel, Heat Resistant, for General Application
ASTM A307	(2014; E 2017) Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM A319	(1971; R 2020) Standard Specification for Gray Iron Castings for Elevated Temperatures for Non-Pressure Containing Parts
ASTM A325	(2014) Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
ASTM A325M	(2014) Standard Specification for Structural Bolts, Steel, Heat Treated, 830 MPa Minimum Tensile Strength (Metric)
ASTM A350/A350M	(2017) Standard Specification for Carbon and Low-Alloy Steel Forgings, Requiring Notch Toughness Testing for Piping Components
ASTM A515/A515M	(2017) Standard Specification for Pressure Vessel Plates, Carbon Steel, for Intermediate- and Higher-Temperature Service
ASTM A516/A516M	(2017) Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate-

	and Lower-Temperature Service
ASTM A688/A688M	(2015) Standard Specification for Welded Austenitic Stainless Steel Feedwater Heater Tubes
ASTM B61	(2015) Standard Specification for Steam or Valve Bronze Castings
ASTM B68/B68M	(2011) Standard Specification for Seamless Copper Tube, Bright Annealed (Metric)
ASTM B88	(2020) Standard Specification for Seamless Copper Water Tube
ASTM B88M	(2020) Standard Specification for Seamless Copper Water Tube (Metric)
ASTM B111/B111M	(2018) Standard Specification for Copper and Copper-Alloy Seamless Condenser Tubes and Ferrule Stock
ASTM B117	(2019) Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM B633	(2019) Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel
ASTM B766	(1986; R 2015) Standard Specification for Electrodeposited Coatings of Cadmium
ASTM C27	(1998; R 2008) Fireclay and High-Alumina Refractory Brick
ASTM C155	(1997; R 2013) Standard Specification for Insulating Firebrick
ASTM C401	(2012) Alumina and Alumina-Silicate Castable Refractories
ASTM C612	(2014; R 2019) Standard Specification for Mineral Fiber Block and Board Thermal Insulation
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
ASTM E230/E230M	(2012) Standard Specification and Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples
ASTM F1097	(2017) Standard Specification for Mortar, Refractory (High-Temperature, Air-Setting)

COMPRESSED AIR AND GAS INSTITUTE (CAGI)

CAGI B19.1	(2010) Safety Standard for Compressor Systems

FM GLOBAL (FM)

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

HEAT EXCHANGE INSTITUTE (HEI)

HEI 2622	(2009) Standards for Closed Feedwater Heaters; 8th Edition
HEI 2623	(2004) Standards for Power Plant Heat Exchangers

INTERNATIONAL SOCIETY OF AUTOMATION (ISA)

ISA 7.0.01	(1996) Quality Standard for Instrument Air

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 6	(1993; R 2016) Industrial Control and Systems: Enclosures
NEMA MG 1	(2018) Motors and Generators
NEMA SM 23	(1991; R 2002) Steam Turbines for Mechanical Drive Service

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
NFPA 211	(2019) Standard for Chimneys, Fireplaces, Vents, and Solid Fuel-Burning Appliances

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION (SMACNA)

SMACNA 1966	(2005) HVAC Duct Construction Standards Metal and Flexible, 3rd Edition

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE J534	(2015) Lubrication Fittings

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-301-01	(2019) Structural Engineering

UNDERWRITERS LABORATORIES (UL)

UL 50	(2015) UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations
UL 353	(1994; Reprint Nov 2011) Standard for Limit Controls

1.2 SUMMARY

****
NOTE: Steam operating pressures will cover a range up to 3.45 MPa 500 psig. However, fire-tube boilers are not generally available above 2.07 MPa 300 psig. This specification is intended to be used primarily with heat recovery incinerators (Section 11 82 19 PACKAGED INCINERATORS), but may be used in other waste heat applications.
****

Provide a facility consisting of [_____] complete steam generation systems (unit systems) with connections to the steam distribution and condensate return systems and auxiliary equipment. Combustion equipment (heat source) is described in Section [23 52 49.00 20 STEAM BOILERS AND EQUIPMENT (500,000 - 18,000,000 BTU/HR)][23 52 53.00 20 STEAM BOILERS AND EQUIPMENT (18,000,000 - 60,000,000 BTU/HR)]. Each steam boiler shall be capable of fully independent or simultaneous operation. The normal mode of operation shall be the same as for the heat source. Combination of unit systems shall be varied to optimize running times; therefore each unit system shall provide identical features to provide redundancy and capability for maintaining continuous operation of the facility at full rated capacity.

1.3 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

Detailed Drawings
Boiler Setting

SD-03 Product Data

Support Steel
Spare Parts
Welding
Framed Instructions
Performance Tests; G[, [_____]]

SD-06 Test Reports

Testing

SD-10 Operation and Maintenance Data

Operating and Maintenance Instructions; G[, [_____]]

1.4 QUALITY ASSURANCE

1.4.1 Welding

****

NOTE: Where pipeline, structural, or other welding is required on the same project, tests will be required accordingly. Testing may be by the coupon method as prescribed in the welding code or by special radiographic methods.

****

Perform all welding in accordance with qualified procedures using performance-qualified welders and welding operators. Procedures and welders shall be qualified in accordance with AWS B2.1/B2.1M or ASME BPVC SEC IX as applicable. Submit a copy of qualified procedures and a list of names and identification symbols of qualified welders and

welding operators. Welding procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by ASME B31.1. Notify the Contracting Officer 24 hours in advance of tests to be performed at the work site if practicable. The welder or welding operator shall apply his assigned symbol near each weld he makes as a permanent record. The welders mark shall not deform or remove metal. Structural members shall be welded in accordance with Section 05 05 23.16 STRUCTURAL WELDING.

1.4.2 Conformance with Agency Requirements

****

NOTE: In lieu of the label or listing, the Contractor may submit a written certificate from any nationally recognized testing organization adequately equipped and competent to perform such services, stating that the items have been tested and that the units conform to the requirements, including methods of testing, of the specified agency.

****

Where materials or equipment are specified to conform to the requirements of, or listed in rating publications of national agencies, proof of such conformance shall be submitted. The label or listing of the specified agency will be acceptable evidence. Where equipment is specified to conform to the requirements of the ASME Boiler and Pressure Vessel Code, the design, fabrication, testing, and installation shall conform to the code in every subject.

1.4.3 Detailed Drawings

Submit detailed drawings, for the specific equipment being proposed, consisting of schedules, performance charts, brochures, diagrams, drawings (including illustrations and equipment placement elevations), instructions, a complete list of equipment and materials, and other information necessary for installation of the steam-generating units and associated equipment, and for piping, wiring devices, trenches, and related foundations. Indicate on the drawings clearances required for maintenance and operation and show complete wiring and schematic diagrams, equipment layout and anchorage, and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. List of materials and equipment shall be supported by descriptive material, such as catalog cuts, detailing conformance with the specification requirements. Catalog numbers alone will not be acceptable. Data shall include the name and address of the nearest service and maintenance organization. Include on the detail drawings equipment connections, complete control wiring, connection diagrams, the proposed plan, elevations, cross section arrangements, and dimensions of the boiler systems. Show on the drawings proposed layout of equipment and appurtenances, and their relationship to other parts of the work to establish that the equipment will fit the allotted spaces with clearance for installation and maintenance. If departures from the contract drawings are deemed necessary by the Contractor, details of such departures, including changes in related portions of the project and the reasons therefore, shall be included with the drawings.

1.5 DELIVERY, STORAGE, AND HANDLING

Protect all equipment delivered and placed in storage from the weather, humidity and temperature variation, dirt and dust, or other contaminants.

1.6 EXTRA MATERIALS

Submit spare parts data for each different item of equipment specified, after approval of the detail drawings and not later than [_____] months before the date of beneficial occupancy. Include in the data a complete list of spare parts and supplies, with current unit prices and source of supply, and a list of the parts recommended by the manufacturer to be maintained in inventory for [_____] months of facility operation.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Provide material, equipment, and controls which are the standard products of a manufacturer regularly engaged in the manufacture of the product and that essentially duplicate items that have been in satisfactory use on at least [three] [_____] jobs for at least 2 years prior to bid opening. To meet the 2 year experience criteria, the heat recovery boiler shall be coupled with the same type of combustion equipment as stated in the bid package. Equipment shall be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the plant site. Controls shall be of a type that has given satisfactory field performance under normal operating conditions for not less than 2 years or 6000 hours before the award of the contract. Types that have been shown to have operated satisfactorily for these periods may have modifications, provided it can be shown that the modifications will not increase maintenance and operating costs and will not decrease the life of the equipment.

2.1.1 Nameplates

Secure a plate to each major item of equipment containing the manufacturer's name, address, type or style, model number, serial number, and applicable equipment rating. Also affix the ENERGY STAR label to the equipment as applicable. Conform nameplates for electrical apparatus to the applicable NEMA Standards.

2.1.2 Equipment Guards and Access

****
NOTE: Catwalk, ladder, and guardrail requirements will be indicated on the drawings.
****

Fully enclose or guard belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts exposed to personnel contact. High-temperature equipment and piping over 66 degrees C 150 degrees F exposed to contact by personnel or where it creates a fire hazard shall be properly guarded or covered with insulation of a type specified. Provide items such as catwalks, operating platforms, ladders, and guardrails where shown, constructed in accordance with Section [08 31 00 ACCESS DOORS AND PANELS][05 51 33 METAL LADDERS].

2.1.3 Prevention of Rust

Unless otherwise specified, surfaces of ferrous metal subject to corrosion shall be factory prime painted with a rust inhibiting coating and subsequently factory finish painted in accordance with the manufacturer's standard practice. Equipment exposed to high temperature when in service shall be primed and finish painted with the manufacturer's standard heat resistant paint to a minimum thickness of 0.025 mm 1 mil. The finish paint shall be a light color.

2.1.4 Use of Asbestos Products

****
NOTE: The first clause in brackets should be used when it is known that substitutes are available for any asbestos products which might be included with the equipment. The second clause in brackets should be used when it is possible or definitely known that asbestos products for which no technically acceptable substitute exists may be included with the equipment.
****

[Products which contain asbestos are prohibited. This prohibition includes items such as packings and gaskets, even though the item is encapsulated or the asbestos fibers are impregnated with binder material.] [Except as provided below, asbestos products are acceptable only in exceptional cases where the Contractor states in writing that no suitable substitute material exists, and in addition, the Contractor furnishes to the Contracting Officer a copy of U.S. Department of Labor, Occupational Safety and Health Administration, "Safety Data Sheet" (Form OSHA-20), completed by the asbestos manufacturer stating that the product is not an asbestos health hazard.]

2.2 BOILERS

****
NOTE: Select the appropriate ASME Standard for the desired pressure class and service specified.
****

Each boiler system shall have the capacity described herein and as shown on the contract drawings. The equipment design and accessory installations shall permit accessibility for maintenance and service. Boilers shall be designed for a maximum allowable working pressure of [_____] kPa psig with an operating pressure of [_____] kPa psig. Design conditions shall be as follows:

Rated capacity	[_____] kg/hour pounds/hour
Steam outlet temperature	[_____] degrees C degrees F
Site elevation	[_____] meters feet
Ambient air temperatures	[_____] to [_____] degrees C [_____] to [_____] degrees F

Reference air temperature	27 degrees C 80 degrees F

The boiler shall be capable of operating continuously at maximum specified capacity without damage or deterioration to the boiler, setting, heat source equipment, or auxiliaries. The boiler shall be capable of automatically controlled operation while coupled to the heat source. Design of the equipment shall be in accordance with the latest ASME Standards; ASME BPVC SEC I, ASME BPVC SEC IV, and ASME BPVC SEC VIII D1. Certification of such compliance shall be evidenced by applicable "P" forms before acceptance of the facility by the Government. Boiler piping shall be provided under ASME B31.1. Each boiler shall be equipped with an [economizer] [air preheater]. Boiler unit or heat recovery section shall be a standard part of a steam generation system package closely coupled to the combustion equipment.

2.2.1 Capacity

Rated capacity shall be the capacity at which the boilers will operate continuously without exceeding the specified boiler heat transfer rates, and boiler exit temperature. Boiler auxiliaries including fans, motors, drives, and similar equipment shall be provided with at least 10 percent excess capacity to allow for field variations in settings and to compensate for any unforeseen increases in pressure losses in appurtenant piping and ductwork.

2.2.2 Electrical Equipment

****
NOTE: Indicate the type and class of motor enclosure depending on the environment in which the motor is to be used.
****

Electric motor-driven equipment specified shall be provided complete with motors and necessary motor control devices. Motors, motor control devices, and power supply wiring shall conform to Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM including requirements for hazardous area locations. Integral size motors shall be the premium efficiency type in accordance with NEMA MG 1. A complete electrical connection diagram for each piece of mechanical equipment having more than one automatic or manual electrical control device shall be submitted for approval before installation. Motors shall be provided with enclosures as indicated.

2.2.2.1 Motor Ratings

Motors shall be suitable for the voltage and frequency provided. Motors 373 W 1/2 horsepower and larger shall be three phase, unless otherwise indicated. Ratings shall be adequate for the duty imposed, but shall not be less than indicated. Motors shall conform to NEMA MG 1 with enclosure as specified. Motors smaller than 746 W Fractional horsepower motors shall be Type I, Class 1B or Class 2A or 2B, Continuous Duty. Motors larger than 746 W Integral horsepower motors shall be Type I or II, Class 2 Continuous Duty, Design L or M.

2.2.2.2 Motor Starters

****
NOTE: Where motor starters for mechanical equipment

are provided in motor control centers, delete the reference to motor starters.
****

Where a motor starter is not shown in a motor control center on the electrical drawings, a motor starter shall be provided. Where required, motor starters shall be provided complete with properly sized thermal overload protection and other equipment at the specified capacity, including an allowable service factor and other appurtenances necessary for the motor control specified. Manual or automatic control and protective or signal devices required for operation specified and any wiring required to such devices, not shown on the electrical drawings, shall be provided. Where two-speed or variable-speed motors are indicated, solid state variable-speed controllers may be provided to accomplish the same function.

2.2.3 Boiler Design Requirements

****
NOTE: Indicate whether the boiler should be fire-tube, water-tube, or can be either one.
****

Each boiler shall be suitable for indoor installation and shall include a heat recovery [fire] [water]-tube section and a steam separator. Tube section shall be designed so the tubes are installed in an arrangement that will permit ease of access and replacement. Boilers shall be fired with the hot gases generated by the associated combustion equipment. Hot gases shall be drawn [through] [over] the tube banks by an induced draft fan. Gas flow shall be controlled by a system of automatically actuated dampers that will route the hot gases through the tube section and out the stack as required to satisfy the operational procedures. Boilers shall be [either] [fire-tube] [or] [single or multiple drum, bare-tube, water-tube, natural circulation]. Sootblowing systems with coordinated controls shall be provided.

2.2.3.1 Radiant Heating

****
NOTE: The following is a guide to determine maximum radiant heat release:

Boiler Type	**Maximum kW/square meter Btuh/sq ft**
Controlled circulation	**water-tube boilers 394.3 125,000**
Natural circulation	**water-tube boilers 315.5 100,000**
	Fire-tube boilers 315.5 100,000

****

The maximum effective radiant heating surface shall be limited to [_____] kW/square meter Btu input per square foot/hour.

2.2.3.2 Combustion Gas

The combustion gas temperature at the furnace exit (boiler entrance) shall

be a minimum of 56 degrees C 100 degrees F less than the ash fusion softening temperature (reducing atmosphere) of any ash contained in the fuel. For boilers attached to waste incinerators this shall not exceed 1093 degrees C 2000 degrees F.

2.2.3.3 Radiant Heating Surface

Effective radiant heating surface for water-tube boilers shall include the flat projected area of bare, metal covered or metallic ore covered tubes and headers, 90 percent of the flat projected area of extended metal or metallic surfaces from the tubes, and the flat projected area of those portions of the first two rows of exit tubes receiving radiant heat from the fire. The flat projected area is defined as the external diameter times the length of the tube. The flat projected area of the extended surfaces shall not include the metal blocks not integral with tubes, extended surfaces less than [_____] mm inch thick or more than [_____] mm inch in length, and the portion of the extended surface which is more than one tube radius from the tube from which it extends. For fire-tube steel firebox boilers it shall be the total water-backed area within the furnace boundaries exposed to the flame. The mean circumference shall be used for corrugated crown sheets.

2.2.3.4 Boiler Operating Capacity

The boiler shall maintain continuous capacity within the specified range while operating on [1][2][3] shifts per day, [_____] days per week schedule at the specified pressure with boiler feedwater at a temperature of approximately [_____] degrees C degrees F. The hot gas entrance temperature shall be [_____] degrees C degrees F and the flue gas outlet temperature shall be [_____] degrees C degrees F, based on a flow of [_____] actual cubic meters/second ACFM. Moisture in the steam and boiler water concentrations shall be in accordance with ABMA Boiler 402.

2.2.3.5 Boiler Output Capacity

****

NOTE: In order to comply with Executive Order 13423 and Public Law 109-58 (Energy Policy Act of 2005), designs must achieve energy consumption levels that are at least 30 percent below the level required by the 2004 publication of ASHRAE 90.1. In accordance with P.L. 109-58 (Energy Policy Act of 2005), Executive Order 13423, and Federal Acquisition Regulation (FAR) 23.203 Energy-efficient Products shall meet or exceed the performance criteria for ENERGY STAR®-qualified or FEMP-designated products as long as these requirements are nonproprietary. The FEMP and ENERGY STAR product requirements are available on the web at www.eere.energy.gov/femp/procurement **and** www.energystar.gov/products**. Where ENERGY STAR or FEMP products are not applicable, energy consuming products and systems shall meet or exceed the requirements of ASHRAE 90.1.**

****

Output capacity of the boilers shall be based on tests of the boilers and combustion equipment as a unit. Efficiency shall be a minimum of [80][_____] percent at maximum continuous capacity.

2.2.3.6 Boiler Markings

****
NOTE: Delete brackets if the boiler does not include a superheater.
****

Each boiler shall also be furnished with a metal nameplate which shall include the following information:

a. Maximum continuous capacity in Watts and Btu/hour Btu/hour.

b. Radiant heating surface in square meters square feet.

c. Total heating surface in square meters square feet.

d. Boiler maximum allowable working pressure.

e. Boiler system ASME Code Stamp and Certification.

f. Maximum steam flow of boiler in kg/hour pounds/hour.

g. Manufacturer's Model Number.

h. Serial Number.

i. Year manufactured.

[j. Superheater final steam temperature in degrees C degrees F.]

[k. Superheater heating surface in square meters square feet.]

2.2.3.7 Noise

****
NOTE: Indicate the noise level required by the location of the equipment. Equipment in remote areas can be allowed to produce noise at a level slightly higher than the normal 85 decibel-A scale (dBA). Occupational Safety and Health Administration (OSHA) regulations and Corps of Engineers safety regulations should be consulted for the most current 8-hour exposure limits.
****

The noise level 304.8 mm 1 foot from a boiler shall not exceed 85 dBA. This includes the boiler, blowers, compressor, and any other noise-producing items related to the boiler.

2.3 BOILER DETAILS

2.3.1 Materials

Materials exposed to the internal environment of the boiler shall be compatible with the temperature and atmospheric conditions which they will encounter. Dissimilar metals that, when in contact or otherwise electrically connected to each other in a conductive solution, generate an electric current, shall not be used in intimate contact.

2.3.2 Lubrication

All sliding, moving, or rotating parts normally requiring lubrication, except those provided with "sealed-for-life" lubrication, shall be provided with suitable means for lubricating. Lubrication points shall be readily accessible and identified by a permanent instruction plate mounted in a convenient location on the boiler. Equipment shall be designed to operate efficiently and satisfactorily when lubricated using standard military lubricants.

2.3.2.1 Lubrication Fittings

Lubrication fittings shall be located in accessible protected positions. A bright red circle shall be painted around each point. Balls, bodies and tips of fittings shall be carbon steel. Threads of fittings shall be 1/4 - 28 taper, straight or 1/8 pipe threads. Fittings shall incorporate a surface ball-check valve located at the surface of the inlet tip. All carbon steel fittings shall be cadmium plated in accordance with ASTM B766, Type I, Class 5 or zinc coated in accordance with ASTM B633, Type I, Class 1 except that the salt spray test period for red rust corrosion shall be a minimum of 50 hours.

2.3.2.2 Caution Plates

When the use of high-pressure lubrication equipment, 6.89 MPa 1,000 psi and higher, will damage grease seals or other parts, a suitable warning or caution plate shall be affixed to the equipment in a conspicuous location.

2.3.3 Lifting Attachments

Each unit shall be equipped with lifting attachments designed and installed to enable the equipment to be lifted in its normal position without undue stress on the unit.

2.3.4 Accessibility

All parts subject to wear, breakage, or distortion, and all parts that require periodic maintenance, shall be readily accessible for adjustment or replacement.

2.3.5 Interchangeability

All parts shall be manufactured to standards that will permit replacement without modification to parts or equipment.

2.3.6 Surfaces

All surfaces shall be finished or painted as specified in paragraph PAINTING AND FINISHING.

2.3.7 Fastening Devices

Bolts and nuts shall be suitable and shall conform to ASME B18.2.1 and ASME B18.2.2 respectively. All screw threads shall conform to the requirements of ASME B1.1. All screws, pins, bolts, hydraulic fittings, and similar parts shall be installed with a means to prevent loss of tightness. Such parts subject to removal or adjustment shall not be swagged, peened, staked, or otherwise permanently deformed.

2.3.8 Electrical

All wiring shall be brought to a single location. Equipment shall be factory wired complete with all necessary accessory devices, so as to require only a source of power at [_____] volts, [_____] phase, 60 hertz, to make the equipment operable. Wiring shall be neat and secure.

2.3.9 Castings and Forgings

All castings and forgings shall be free from defects such as scale, mismatching, blowholes, or any other defect that will affect life or function of the part. Cast gray iron shall conform to [ASTM A278/A278M] [ASTM A48/A48M], cast iron shall conform to ASTM A319, and heat resistant alloy shall conform to ASTM A297/A297M Grade HF.

2.3.10 Welding, Brazing, Soldering, Riveting, or Wiring

Welding, brazing, soldering, riveting, or wiring shall be employed only where these operations are required in the original design.

2.3.11 Refractory and Insulation

Refractory and insulation systems shall be manufacturer's proven standard design. Manufacturer shall submit temperature estimates, material quality information, and description of installation methods in sufficient detail to permit evaluation of the materials and methods used. Construction materials and methods must be approved before manufacture. Plastic refractory shall be installed in accordance with the manufacturer's recommendations and by workmen skilled in its application. Insulation systems shall be manufacturer's proven standard materials and methods and shall be submitted with data as to adequacy of material. Hot spots exceeding requirements shall be field repaired as directed. Exposed areas to be field installed shall be as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.3.11.1 Insulation

Where specified or indicated, insulation shall be insulating block containing no asbestos material, designed to prevent damage to foundation and boiler exterior due to excessive heat. Comply with EPA requirements in accordance with Section 01 33 29 SUSTAINABILITY REQUIREMENTS AND REPORTING. Insulation shall be Class 5 mineral fiber block conforming to ASTM C612. Insulating block shall be laid in approved mortar specifically manufactured for this purpose or recommended by the insulating material manufacturer. Firebrick shall conform to ASTM C27 and ASTM C155. Firebrick shall be interpreted to include straight brick, radial brick, wedge brick, skew-type brick, cupola blocks, and other similar shapes. Firebrick shall be laid up in air-setting mortar. Each brick shall be dipped in mortar, rubbed, pushed into place, and then tapped with a wooden mallet until it touches the adjacent bricks. Mortar thick enough to lay with a trowel will not be permitted. Mortar shall conform to ASTM F1097. Maximum mortar joint thickness shall not exceed 3.2 mm 1/8 inch and average joint thickness shall not exceed 2.0 mm 1/16 inch. Main arches of the boiler and flue connection shall be insulated above the firebrick and, where exposed to the weather, shall be protected with a suitable concrete or brick slab. Firebrick floors shall be insulated from the supporting floors with insulating brick except that if the supporting floor has full bearing on earth, a 75 mm 3 inch layer of contained dry sand may be used

in lieu of insulating brick. Minimum thickness for walls shall be [_____] mm inches to limit the temperature of the outer casing to 49 degrees C 120 degrees F in an ambient temperature of 21 degrees C 70 degrees F when the unit is operating at full rated capacity, and as determined by a surface pyrometer.

2.3.11.2 Expansion Joints

Joints shall be provided in the firebrick masonry at [approximately the locations shown] [spacings of approximately 2.44 meters 8 feet]. Joints shall be 12.7 mm 1/2 inch wide and shall completely separate the sections without any interlocking of the bricks. [The locations may be changed from those indicated by as much as 300 mm 12 inches in either direction for convenience of construction and shall be changed as necessary, by offset or otherwise, to avoid weakening the arch over an opening.] No expansion joint shall be closer than 300 mm 12 inches to the vertical side of an arched opening or to the top of the brick forming the arch over the opening. When joints are offset, there shall be no bonding of the horizontal faces between the two courses of brick along the offset. In addition, to allow for expansion of the inner face, a series of 3.2 mm 1/8 inch wide vertical openings spaced 1.8 m 6 feet apart shall be provided on the furnace side of the wall. Proper provision shall be made for expansion and contraction between boiler foundation and floor.

2.3.12 Boiler Setting

Boiler shall be constructed to comply with ASME BPVC SEC VIII D1 and shall be provided with insulation, steel base, water column with gauge, automatic feed water pump control and low water cutoff, steam pressure gauge, relief valve, automatic steam pressure control and blowoff, and soot-blower. Submit complete setting plans, certified by the boiler manufacturer.

2.3.12.1 Boiler Foundation

Foundation structure shall be provided and installed in accordance with manufacturer's recommendations and as indicated. Structural systems supporting pressure parts, tubes, and refractory shall have a safety factor to permit delivery of boiler, jacking, and rigging.

2.3.12.2 Supports

Boilers and separator drums shall be provided with support lugs and saddles to provide an adequate and firm installation to the foundation structure. Supports are to provide for free expansion and contraction of each part of the boiler without placing undue stress on any part of the boiler or setting.

2.3.12.3 Shell

Casing or shell sides shall be constructed of carbon steel materials not lighter than 3.416 mm 0.1345 inch thick, either bolted or welded. Casing shall be gas-tight and shall be reinforced with steel ribs or stiffeners to provide rigidity and prevent buckling. Boiler casing shall be fully insulated with sufficient thickness to limit the casing temperature as specified. Boiler shell shall be equipped with all necessary connections including outlet nozzles, return connections, and connections for pressure relief valves, water level controls, and other required trim. Manholes, handholes, and observation ports shall be provided in accordance with

ASME BPVC SEC I. Boilers shall be equipped with gas-tight observation ports.

2.3.12.4 Expansion and Contraction

Adequate provisions shall be made for expansion and contraction of the boiler unit and associated breaching to prevent damage to the support structure or the equipment and associated ductwork. Provisions shall be made for expansion and contraction between boiler foundation and floor. Joints shall be packed with oakum and filled with a suitable compound that will not become soft at temperatures of 49 degrees C 120 degrees F.

2.3.13 Water-Tube Boiler

Boiler shall be a shop fabricated and field erected or a packaged unit. Boiler shall include water walls, soot-blowers, [economizer,] [super heater,] and steam drums to withstand temperatures existing under maximum load conditions to ensure production of the steam as specified. Boiler shall include setting refractory, insulation to maintain a casing temperature of not greater than 55 degrees C 130 degrees F with a surface air velocity at 5.4 km/hour 5 feet/second and an ambient temperature of 26 degrees C 80 degrees F while boiler is operating at maximum capacity (no asbestos material shall be used), and welded or doubled wall casing. Access opening covers shall be hinged.

2.3.13.1 Drums or Dome Space

For water-tube boilers, each drum or dome space shall be steel plate, fusion welded in conformance with ASME BPVC SEC I, including stress relieving and x-raying of welded seams. The main steam drums shall be of sufficient size to accommodate steam separators and drum internals with provisions and space for accomplishment of maintenance. Baffling shall be provided to separate the steam from the water in the drum and to maintain a stable water level under a fluctuating load. Variations in normal water level shall not exceed 50 mm 2 inches with an increasing load change of 20 percent of rated capacity per minute. Steam separators shall be provided to deliver saturated steam with a maximum specified moisture content. Each drum shall have two 300 by 400 mm 12 by 16 inch elliptical manholes, with the exception of the mud drum which shall have at least one 300 by 400 mm 12 by 16 inch elliptical manhole. Each manhole shall have a cover, yoke, and gaskets.

2.3.13.2 Drum Outlets

Drum outlets shall be applied in approved manner and of approved strength in accordance with ASME BPVC SEC I. Outlets shall include but not be limited to:

a. Steam nozzle of 2.07 MPa 300 pounds, flanged to receive specified nonreturn stop and check valve, and able to withstand forces and moments imposed by connected piping. Studdery will not be permitted.

b. Boiler vent on shell or steam drum as approved by ASME BPVC SEC I, to be equipped with 2.07 MPa 300 pound steel steam gate valve, nipples, and ells to vent away from operator.

c. Safety valve outlets in required number and size, located approximately as indicated, or as necessary to permit straight run of vent through roof.

d. Water column and low water cutoff connections with outside screw and yoke (OS & Y) valves, [lockable,] [and with locks and keys furnished].

e. Connections for boiler water feed, chemical admission, continuous blowdown and water sampling combined, located as indicated on plans.

f. Intermittent blowdown connections.

g. Water level sensor connections (for level control).

h. Pressure gauge and pressure switch connections.

2.3.13.3 Tubes

Tubes shall be of the diameter and arrangement that best suits the manufacturer's recommendation to meet the specified design criteria. Tubes shall be electric-welded or seamless steel, and shall be connected to the drums and header by being expanded into bored tube seats (standard fit) or by being welded in accordance with ASME BPVC SEC IX. Tube wall thickness shall be at least the minimum recommended by the manufacturer. Finned tubes shall be allowed only when the fuel is gas or oil and shall provide a continuously welded bond between the tube surface and the helically wound fin. Tube materials shall comply with ASTM A192/A192M and provide optimum life expectancy and corrosion resistance. Tube headers, channels, and manifold pipes shall provide sufficient volume to ensure no part of the boiler will become water-starved. Radii of all bends in tubes shall be such that standard turbine type cleaners can easily pass through for cleaning of full length of tubes.

2.3.13.4 Baffles

Baffles shall be arranged to bring the products of combustion into contact with the heating surfaces without excessive loss of draft. Baffles shall be gas-tight and shall be either a refractory material or metal suitable for temperatures encountered.

2.3.14 Fire-Tube Boiler

Boiler shall be packaged type and shall include programming control system with capacity as indicated. Access opening covers shall be hinged.

2.3.15 Boiler Internals

2.3.15.1 Internal Fittings

Internal fittings shall be securely mounted and demountable for boiler access and cleaning and shall include but not be limited to:

a. Boiler feedwater admission system to properly distribute feedwater.

b. Chemical feed piping to permit infusion of caustic, phosphate, and water mixture by continuous feed system.

c. Continuous blowdown and water sampling system as combined unit.

d. Intermittent blowoff system to properly collect mud from bottom and permit drainage of boiler without water accumulation.

2.3.15.2 Outlet Fittings

Outlet fittings shall be flanged above 50 mm 2 inches. but may be threaded for 50 mm 2 inches and smaller. [Note that all boiler systems (steam, feedwater, and intermittent blowdown) operate into common headers serving more than one generator.] All devices, designs, and piping methods shall be in full accordance with applicable provisions of ASME BPVC SEC I for pressure piping and shall be evidenced by proper certificates of work performance and inspection.

2.3.15.3 Openings

Steam outlets, safety valves, and other valve openings in outer casing at top of boiler shall be flashed or sealed in a manner to prevent water leaking into the casing insulation.

2.3.15.4 Settling Chamber

****

NOTE: Requirement for Settling Chamber is an option depending on the fuel at the heat source.

****

Settling chamber for removal of fly ash, equipped with suitable means for frequent cleaning without shutting down the boilers, shall be provided below the last pass of each boiler.

2.3.16 Access Doors

Access doors in sufficient number, of adequate size, and properly located shall be provided for cleaning, inspection, and repair of all areas in the complete assembly. Doors shall be gas-tight and interior surfaces exposed to direct radiant heat and high temperatures shall be lined with approved refractory material to prevent excessive heat losses and warping of doors. Doors too large or bulky for hand removal shall be hinged. At least one observation port with cast-iron cover shall be provided on each door of the boiler. An electrical interlock shall be provided to prevent the tube cleaning system from operating unless the doors are closed and latched. Door casing shall be of the same material and thickness as the adjoining boiler casing. Door lining shall consist of 50 mm 2 inches of block insulation and 102 mm 4 inches of heavy castable refractory conforming to ASTM C401, Class R. Doors shall be equipped with high temperature gaskets and door latches.

2.3.17 Miscellaneous Pipe Connections

Miscellaneous pipe connections shall be provided for steam outlet, safety valves, feedwater, feedwater regulator, water column, blowoff, steam supply to soot blowers, steam gauge and vent, continuous blowdown, continuous chemical feed, and instrument connections. Soot blowers shall be provided if the combustion source utilizes solid fuel. A suitable smoke outlet with steel frame, damper, and damper shaft shall be provided. Damper shall have external high temperature roller or ball bearings at both ends of the shaft, and shall have a suitable operating arm and rod.

2.3.18 Observation Ports

****

NOTE: Requirements for observation ports and test holes depend upon the specific project, including competence and availability of operating and maintenance personnel, type of fuel to be burned, etc. The number and location of the test holes will conform to the requirements of the regulatory authority. In addition, test holes for monitoring operating efficiency will be provided as shown.
****

[One] [Two] observation port[s] 80 mm 3 inches in diameter shall be provided on each access door and shall be no less than 2.657 mm 12 gauge black steel or cast iron tube or duct with a heat resistant glass cover or an angular steel frame and closure plate with handle for operation without gloves or other protective devices. Tube or duct shall extend from the exterior of the casing to not less than one-half the thickness of the refractory opening and shall be gas-tight. Provision shall be made for air purging of the port when solid fuels are used at the heat source.

2.3.19 Test Holes

****
NOTE: Coordinate with paragraph Observation Ports.
****

Test holes shall be provided as indicated and shall be fitted with standard weight, 50 mm 2 inch diameter, black steel pipe. Sleeve shall extend from the exterior of the casing to not less than one-half the thickness of the refractory lining. Refractory opening shall be formed from the end of the pipe sleeve to the interior wall surface to shield the end of the sleeve from reflected heat. Sleeve shall be fitted with a brass screw cap and security chain. Each test pipe shall have two or more sturdy lugs welded in approximately the middle of its length to prevent the pipe from turning when the cap is being removed.

2.3.20 Safety Devices

Boilers shall be provided with safety devices providing automatic overheat shutdown and manual shutoff of the combustion equipment or flue gas dampers to bypass the boiler.

2.3.21 Freeze Protection

Low points of all piping and tubing shall be equipped with drains for freeze protection.

2.3.22 Fire Protection

Boilers shall meet the requirements of NFPA 85.

2.4 BOILER AUXILIARY EQUIPMENT

2.4.1 Boiler Fittings and Appurtenances

Boiler fittings, and all other boiler appurtenances shall comply with ASME BPVC SEC I. Boilers shall be provided with a continuous blowdown connection from an internal pipe running the length of the steam drum at the point of the highest concentration of dissolved solids. Blowoff provisions shall be provided from the mud drum or lower part of a

fire-tube boiler. Pressure gauges for high-pressure steam units shall include a siphon, gauge cock, and test connection. Trim and appurtenances shall include a 150 mm 6 inch minimum pressure gauge and a safety valve. A chemical feed connection with internal distribution pipe shall be provided.

2.4.1.1 Water Column

Water column with straight-through type drain valve shall be provided. Water column shall be complete with gauge glass, high- and low-water alarm, and three quick-closing gauge valves and try cocks fitted with the necessary chains and handles for operation from the boiler room floor. Water column shall also include a test valve, blowdown valve, and a straight-through type drain valve. Water column shall not be combined with the low water cutoff. [Water column lighting shall be provided for ease of reading at all times.]

2.4.1.2 Low Water Cutoff

****

NOTE: When the boiler is used as a "heat recovery unit," an alternate path is usually provided to vent or bypass the hot gases in the event the boiler is unable to perform its function. In all other cases, activation of the low-water cutoff will cause the loss of all support to the combustion process including loss of combustion air and fuel.

****

A low-water cutoff, with alarm located on instrument panel, shall include either a float-actuated switch as a means of making electrical contact or an electrically-actuated probe type low water cutoff. The float chamber shall be provided with a blowdown connection. The cutoff shall cause a safety shutdown and sound an alarm when the boiler water level drops below a safe minimum level [and hot gases from the combustion equipment shall be routed to the bypass stack]. [Two low-water cutoffs shall be installed on each boiler. Low-water cutoffs for the boilers shall be piped separately with separate drum connections. Each low-water cutoff shall have a separate housing. Two elements in one housing will not be permitted.] A safety shutdown due to low-water cutoff shall require a manual reset before operation can be resumed and shall prevent recycling of the combustion equipment. The cutoff shall be in strict accordance to the latest version of code, ASME CSD-1, Controls and Safety Devices for Automatically Fired Boilers.

2.4.1.3 Feed and Check Valves

Feed and check valves shall be provided adjacent to each boiler feed nozzle.

2.4.1.4 Continuous Blowdown Valve

****

NOTE: Continuous blowdown equipment will be provided as required by UFC 3-410-01 or UFC 3-410-02. If a fire-tube boiler is specified, these paragraphs will be deleted.

****

Continuous blowdown valves shall be manual proportioning, fabricated of corrosion-resistant steel. Valves shall have a micrometer dial setting and shall be provided with a chart listing the capacities through the complete range of micrometer settings at the boiler pressure. Valves shall conform to ASME BPVC SEC I. Blowoff valves in tandem shall be provided at each point of blowdown as recommended by the boiler manufacturer. Piping shall be extra-heavy weight, minimum, steel pipe conforming to ASTM A106/A106M Grade B. Slow opening valves shall be balanced, seatless type unless otherwise approved. Both surface and bottom blowdown connection points with required accessories shall be provided. Valves shall have a capacity equal to the capacity of the boiler and shall have forged steel bodies with socket weld connections. Valve shall have a solid Stellite disk with stainless steel seat sleeves. The bodies shall be designed for a minimum working pressure of 2.07 MPa 300 psig. Quick opening valves shall be lever operated, flat seat sliding disks with sealing bushing on the inlet side, and shall be double tightening on both sides of the disk. Quick opening valves shall be gear operated. All blowoff valves shall be suitable for safe blowdown through the piping system installed. All pipe, valves, and fittings shall be supplied as necessary to allow tie-in to a central point for surface and bottom blowdown.

2.4.1.5 Safety Valves

Safety valves of proper size and of the required number and construction and set pressures shall be in accordance with ASME BPVC SEC I and shall be installed so that the exhaust steam will discharge through pipes extending through the roof. Each exhaust riser shall have a drip-pan elbow to prevent the accumulation of water on the valve. A suitable slip joint shall be provided between the drip-pan elbow and the riser. Each exhaust head shall be one-piece construction of plate steel, semisteel, or cast iron, equipped with suitable baffle arrangement and drain connection for removing entrained condensate and oil. Flow area through the valve shall be larger than through the connecting pipe. Valves shall be set to discharge at 10 percent above the operating pressure of the system.

2.4.1.6 Steam Nonreturn Valves

Steam nonreturn valves of size and pressure rating shown shall be installed in the steam supply line from each boiler. Valves shall be arranged to close automatically when there is a pressure differential of 35 kPa 5 psi between the boilers and steam headers, and shall be arranged to operate as stop valves. Valves shall be set with stem up, either inclined or vertical, and shall be of the rising stem type. Valves shall be of the angle or straight-way type and shall operate without chattering, hammering, or sticking. Valves shall be cast steel.

2.4.1.7 Feedwater Regulator

Feedwater regulator, sized for the application, shall be connected complete with all necessary piping and accessories for automatic operation. Valved bypass shall be provided around the control valve. Units shall be provided with a device to lock the regulator in existing position in case of power failure. Unit shall be provided with a manual/automatic selector panel located on the instrument panel in the control room. The feedwater control element shall be provided with a drain valve. The feed-water line shall be fitted with a thermometer well. Mechanical linkages and chains to position the valve will not be allowed. Feed-water piping shall conform to the requirements of

ASME BPVC SEC I. A hand wheel or a manual jacking device shall be provided to permit manual operation of the regulator valve.

2.4.1.8 Soot Blowers

****

NOTE: Soot blowers should be required for all boilers when solid fuel is burned, and are advisable when burning No. 6 fuel oil. If only gas or No. 2 fuel oil is being burned, this paragraph may be deleted. Soot blowers are available for fire-tube boilers.

****

Soot blowers shall be provided in conjunction with the heat recovery or boiler section of each solid fuel fired steam generation system. Soot blower or cleaning nozzles shall be furnished in sufficient numbers, permanently mounted, and so arranged or spaced to effectively clean all tube surfaces. Each soot blowing system shall be an automatic sequencing, flexible operation using air or steam as the blowing medium. Elements within the boiler shall be constructed of heat-resisting alloys suitable for the flue gas temperature encountered and shall be removable without disturbing the boiler tubes. If the soot blowers are air operated, air compressors with sufficient capacity to accommodate the additional load of the soot blowers shall be provided. [Each boiler unit shall include a cyclone separator installed in conjunction with the boiler stack to capture particulate matter emitted during tube cleaning operations.] Frequency of the cleaning operation shall be automatically controlled by timers that shall be interlocked with the inspection doors to prevent cleaning when the doors are open. Each blower unit shall be furnished complete with all necessary auxiliaries, controls, and equipment and shall be connected according to the manufacturer's recommendations.

2.4.1.9 Drains

Drains consisting of a 20 mm 3/4 inch hose bib or a 25 mm 1 inch hose gate valve shall be installed at the lowest point in the return main near the boiler and at locations shown or as required for the convenient and thorough draining of the system.

2.4.2 Economizers

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NOTE: The economizer or air preheater will be selected to be compatible with any pollution control equipment being utilized. Finned tubes will not be used for solid fuels.

****

Economizers shall be of a type normally provided by the boiler manufacturer and shall include [finned tubes,] [bare tubes,] baffles and headers and shall have provision for cleaning and tube bundle removal. At maximum load, economizer exit water shall not be within 17 degrees C 30 degrees F lower than saturation temperature. Materials shall be capable of withstanding the maximum boiler exit gas temperature plus 28 degrees C 50 degrees F. Tubes shall conform to ASME BPVC SEC I. Overall design and installation shall preclude cold-end corrosion under any load condition. Economizer exit flue gas temperature shall not be less than 177 degrees C 350 degrees F and the tube metal temperature shall be above the maximum

flue gas dew point for the fuel being fired under all load conditions.

2.4.3 Air Preheaters

****

NOTE: The economizer or air preheater will be selected to be compatible with any pollution control equipment being used.

****

Air preheaters shall be of a type normally provided by the boiler manufacturer and shall be recuperative, tube plate, or regenerative type constructed of materials adequate to withstand the corrosion effects of the flue gases. Overall design shall preclude cold-end corrosion of the air preheater under any load condition. Temperatures of all metals in contact with flue gas shall be above the flue gas maximum dew point temperature for the fuel being fired under all load conditions. Control shall be by steam preheat or by automatic bypass and shall be integrated with the combustion control system.

2.4.4 Draft Fans

****

NOTE: Where induced draft fans are installed directly after the heat recovery boiler, it may be necessary to provide liners for scroll sheets and rotor blades if the gases contain particulates in excess of 229 mg per dry standard cubic meter (0.10 gr/DSCF). The fan design and construction will be strongly influenced by the type of particulate control device used and its location relative to that device.

****

Furnish induced draft centrifugal fans, as specified, as an integral part of the boiler design. The unit shall consist of an electrical motor driven centrifugal fan, a housing (scroll and side plates), controls, guards and accessories. All components shall be attached to a common base which shall include provisions for fastening to a foundation. The unit shall be completely assembled, ready for installation and operation.

a. Fan assemblies shall be suitable for continuous boiler draft operation to handle flue gases having temperatures up to 800 degrees F. Fans shall comply with AMCA 99 standard applicable to centrifugal furnace fans and shall be rated for flow rate, pressure, power, speed of rotation and efficiency in accordance with AMCA 210 and ASME PTC 10. The supplier shall submit to the Contracting Officer satisfactory evidence that the fan furnished meets the requirements of AMCA 210. Acceptable evidence of meeting the requirements of this standard will be the AMCA Certified Rating Seal or a certified inspection report from an independent testing laboratory indicating that the fan conforms to the requirements of AMCA 210.

b. Fans shall be centrifugal with backward curved blades or radial tip blades. Each fan shall be sized for operation at an elevation of [_____] meters feet, with an output volume and equipment, leaks, and temperature and elevation corrections for a dirty boiler with worst ambient conditions, all at full combustion. In addition, fan sizing shall include margins of 10 percent excess volume against a 21 percent

static pressure and air temperature 22 degrees C 40 degrees F above operating temperature.

c. Induced draft fans shall be designed for handling hot flue gas at the maximum boiler outlet temperature adjusted for boiler surface fouling. Fans shall be of the [single] [or] [double] width centrifugal type. [When the fan is a double-width centrifugal type, it shall have a double inlet.] The direction of fan rotation shall be [clockwise] [or] [counterclockwise] as determined from the drive side of the fan. The direction of discharge shall be [top horizontal] [top angular down] [down blast] [bottom angular down] [top angular up] [up blast] [bottom angular up] [or] [bottom horizontal]. The position of inlet box shall be [45] [90] [135] [180] [225] [270] [315] [or] [360]. The fans shall have a static efficiency of not less than 0 percent in standard air at best efficiency point. Fan wheel shall be constructed of [steel] [or] [aluminum]. The shaft shall be turned, ground, and polished. The fan wheel and shaft assembly shall be balanced statically and dynamically. The complete rotating assembly of the fan shall be dynamically balanced within the limits of the following formula:

$$\text{Vibration displacement} - \frac{1.620}{\text{mills-peak-to-peak revolutions per minute}}$$

Noise levels for fans shall not exceed 85 dBA at a 914.4 mm 3 foot station. The fan housing shall be carbon steel of a nominal thickness not less than that selected in Table I.

TABLE I HOUSING GAUGES		
Nominal fan diameter (mm) (inches)	Sides	Scroll
up to 584 23	3.42 mm (10 gauge) 10 gauge	3.42 mm (10 gauge) 10 gauge
600-68524-27	4.55 mm (7 gauge) 7 gauge	4.55 mm (7 gauge) 7 gauge
1855 73 and over	6.35 mm 1/4 inch	6.35 mm 1/4 inch

Scroll and sideplate joints shall be continuously welded. The housing shall be reinforced with steel member to provide a rigid structure and to minimize vibration. [A threaded drain connection to accommodate a 25 mm 1 inch standard pipe shall be located at the lowest point in the scroll. A flush-type access door shall be included in the scroll and held by quick-release clamps and located as specified. Inlet and outlet duct connections shall be flanged]. [The inlet of the fan shall be equipped with an inlet box of the same steel thickness as the housing.] Seals shall be provided to minimize leakage where the shaft passes through the housing or inlet box. [Scroll sheets and rotor blades shall have liners.]

a. Induced draft fans shall be insulated as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Fans shall be factory painted with the manufacturer's standard finish. If drawings so indicate, the induced-draft fan housing shall be designed to support the portion of the boiler stack that is resting on the housing. Fans shall have [inlet vane control] [inlet damper control] [variable speed control]. Inlet vanes or dampers shall be suitable for use with combustion control equipment. The fan shall be equipped with

[precision anti-friction bearings that meet the requirements for a minimum rating life of 100,00 hours] [the self-aligning sleeve type] [or] [roller bearings mounted in suitable pillow blocks]. Fans with backward curved blades may have self-aligning anti-friction bearings.

b. Fan bearings shall be air cooled. Air balanced pillow blocks or auxiliary seals shall be provided to prevent the aspiration of oil from oil slinger type bearings. The oil reservoir shall be provided with heat slingers for control of air movement over the bearing housing in order to prevent a buildup of ambient temperature. Means for lubrication shall be provided in accordance with the manufacturer's standard practice. Parts requiring lubrications shall be so located as to make the lubricating points easily visible and accessible. Hydraulic lubrication fittings shall be in accordance with SAE J534. Where use of high-pressure lubricating equipment, 1000 pound-force per square inch or higher, will damage grease seals or other parts, a suitable warning shall be affixed to the equipment in a conspicuous location. All parts requiring lubrication shall be properly lubricated before delivery.

c. Fans shall be driven by electric motors. Electric motor shall be [drip proof] [totally enclosed, nonventilated] [totally enclosed, fan-cooled] [totally enclosed, fan-cooled, suitable for installation in a Class 1, Division 1, Group F, hazardous location conforming to NFPA 70]. Motor starter shall be magnetic [across-the-line] [reduced voltage start] with [general-purpose] [weather resistant] [watertight] [dust-tight] [explosion-proof] enclosure and shall be furnished with four auxiliary interlock contacts. Fans shall be directly or indirectly connected to the driving motor. If the fan is indirectly connected, a V-belt designed for 50 percent overload capacity shall be provided, and the motor shall be mounted on the base in a manner that will permit tightening of the belt.

2.4.5 Flue Ducting

Each boiler shall be connected to the stack or flue by means of a smoke connection constructed of black iron or steel sheet not less than 1.214 mm 0.0478 inch, nominal thickness. Clear distance between any portion of the smoke connection surface and any combustible material shall be not less than that specified in NFPA 211. Joints and seams shall be securely fastened and made airtight. Suitable clean-outs shall be provided to permit cleaning the entire smoke connections without dismantling. Duct construction shall conform to SMACNA 1966. Plastic materials polyetherimide (PEI) and polyethersulfone (PES) are forbidden to be used for vent piping of combustion gases.

2.4.6 Breaching

Breaching shall be constructed of not less than 3.416 mm 10 gauge steel sheets conforming to ASTM A36/A36M. Breaching shall be adequately reinforced and braced with structural steel angles not smaller than 50.8 by 50.8 by 6.4 mm 2 by 2 by 1/4 inch and all joints and seams in the sheets and angles shall be welded. Expansion joints shall be installed as indicated and as required to suit the installation and shall be flexible type requiring no packing. Breaching shall have angle flanges and gaskets for connection to boilers, fans, equipment, or stacks with breaching to be the full size of the opening. Breaching shall be lined with a minimum of 76.2 mm 3 inch thick refractory. Breaching connections shall be gas-tight, caulked tight all around and sealed with cement to form an

air-tight joint. Clean-out openings of suitable size and at approved locations shall be provided for access to all sections of the breaching and shall have tight-fitting hinged doors with frames. One 400 by 400 mm 16 by 16 inch inspection door shall be located in the side of the breaching just preceding the boiler unit. A similar inspection door shall be located just following the boiler unit. Breaching may be supplied in bolted or welded sections for ease of handling and erection and shall be constructed in accordance with SMACNA 1966. Connectors shall be in accordance with NFPA 211. Plastic materials polyetherimide (PEI) and polyethersulfone (PES) are forbidden to be used for vent piping of combustion gases.

2.4.7 Flue Gas Inlet Damper

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NOTE: Optional wording is applicable to guillotine-type dampers.
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A [guillotine] [butterfly] [shutter] damper [of the thickness indicated] [at least 63 mm 2-1/2 inches thick] and consisting of refractory material enclosed in a steel frame shall be installed at the entrance of the waste heat recovery boiler to isolate it from the combustion equipment during emergency boiler repairs. A [chain hoist] [manual lever] [electrical control] for raising and lowering the damper shall be furnished and shall be of a size and design to ensure free movement by the damper. [The hoist cable shall be secured to the damper frame by shackles and bolts. The damper slot shall have a steel plate cover 6.4 mm 1/4 inch thick and of the proper length and width. The cover shall have a slot to permit passage of the damper cable, and for easy removal of the damper. The hoist shall be a product of a manufacturer regularly engaged in the manufacture of hoists. Hoist shall be spur geared. Unit shall be designed for high-speed lifting, have high mechanical efficiency, an automatic load brake, and a built-in load limit.] The operator shall be able to move the required load freely and maintain the damper in any desired position within the limits of the flue opening. Maximum pull to operate the unit shall not exceed 310 Newtons 70 pounds.

2.4.8 Flue Gas Discharge Dampers

A controller-actuated, refractory-lined damper shall be installed at the boiler exit. Another damper shall be installed in the dump stack and shall open if any of the following conditions occur:

a. Excess boiler steam pressure.

b. Induced draft fan failure.

c. Boiler is shut off.

Boiler dampers shall be operated by a controller-actuated motor based on the [boiler steam pressure] [boiler water temperature]. Boiler and dump stack dampers shall be reverse acting, i.e., when the boiler damper is open, the dump stack damper will be closed.

2.4.9 Blowoff Tank

Blowoff tank [shall be constructed of 4000 psi reinforced concrete as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE, and shall be fitted

with a bolted steel manhole cover and frame. Blowoff pipe, vent pipe, and drain pipe to sewer shall be installed in pipe sleeves built into the concrete. Space between the pipe and sleeves shall be filled and caulked with lead wool or similar material to make a water-tight connection. Tank shall be divided into two sections by a baffle to form a sediment chamber] [shall be constructed of steel].

2.4.10 Boiler Feed Pumps

Boiler feed pumps shall be sized and designed for the specific application. Pumps having a combined rating of flow and head that results in a horsepower rating less than 186 kW 250 bhp shall be furnished to meet the design requirements of API STD 610. The pump shall be either end-suction or top suction, top-discharge and be supported at the center line. Pump size with higher ratings than the above shall be horizontal-split case, multistage centrifugal pumps. All pump ratings shall have, nominally, an excess capacity of 10 percent above the maximum continuous rating of the service. The required net positive suction head (NPSH) at the pump design flow, head, and speed shall not exceed 80 percent of the available system NPSH at the same flow, assuming a low level in the storage tank. The guaranteed NPSH requirements shall reflect 3 percent breakdown criteria. The pump's head-capacity (H-Q) curve shall be constantly rising to shutoff with no point of inflection. There shall be no restriction to operation at any point from continuous flow to design flow. Pumps shall be turbine type, bronze fitted throughout, with impellers of bronze or other corrosion-resistant metal as approved. Pump barrel assemblies shall be fitted with lifting rings. Capacities and characteristics shall be as indicated.

2.4.10.1 Casings

Casing construction shall be either volute or diffuser design and shall be supported at its centerline. Pumps shall have integrally cast suction and discharge flanges that shall be drilled to meet the design pressure of the application. The maximum operating temperature, for design purposes, of any feedpump shall not be less than 204 degrees C 400 degrees F. Casings shall be drilled, tapped, and provided with vent, gauge, and drain connections. Pumps designed for this service shall not require cooling at ratings below 370 kW 500 bhp. This applies to both frame cooling or seal cooling. Below 370 kW 500 bhp, pumps shall employ antifriction radial and thrust bearings lubricated by flinger rings in a sealed housing. Seals shall be mechanical and air-cooled flush piping conforming to API STD 610, Plan 23. Above 370 kW 500 bhp, pumps shall employ a single cooling circuit for both cooling and the oil being delivered by a forced-oil system to sleeve radial bearings, and a floating shoe thrust bearing, coupled with the seal coolers for both stuffing boxes. Mechanical seals shall also be provided, and an extra seal replacement kit shall be provided for each pump. In both cases, stuffing boxes shall be site-convertible to a packed box. Leakage shall be not more than 25 cc/hr for a seal life of not less than 25,000 hours. Bearing rating shall be not less than 100,000 hours (L-10 life) at the point of maximum load, as defined by ABMA 9. Sump cooling shall be by indirect coil. Pump casings shall be designed to allow the pump barrel assembly to be removed as a unit, from the drive shaft end to the impeller, without disturbing the main piping or the drive [motor] [or] [turbine].

2.4.10.2 Pump Base

Pumps shall be supported on structural steel bases that do not require

grouting in order to impart strength to the pump for static and dynamic loading from the piping system. Bases for pump and drive assembly and support shall be complete with drain lip and pitched to a low-point drain. The complete pump and motor assembly shall be shop aligned using shims on both the pump and motor. Pumps shall be installed on their concrete foundations where shown on the drawings.

2.4.10.3 Pump Couplings

All pumps shall be furnished with nonlubricated flexible-disk couplings and a coupling guard. Couplings shall be spacer type to permit removal of the mechanical seals and limited-end-float-type for pumps with sleeve bearings.

2.4.10.4 Pump Relief Valve

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NOTE: If automatic recirculation valve is utilized, delete this paragraph.
****

Where an automatic boiler feedwater recirculation valve is not used, each boilerfeed pump shall be arranged for continuous operation and shall be furnished with a suitable relief valve for bypassing the boiler feed to the deaerating feedwater tank to maintain a minimum flow of 5 percent under shutoff conditions. Feedwater regulating valve shall maintain a constant feed-pump discharge pressure. Valve shall be an internal-pilot-operated piston valve, single-seated, V port or tapered plug, and shall be adjusted to maintain within 7 kPa 1 pound of the desired terminal pressure, regardless of fluctuations in the initial pressure or fluctuations in the rate of flow. Valve body shall be constructed of bronze with renewable disks and seats of hardened stainless steel and shall be designed for a working pressure of not less than [1.72] [_____] MPa [250] [_____] psig. A position indicator shall be provided with the valve.

2.4.10.5 Pump Shutoff Valve

Each pump shall be fitted with a shutoff valve on the suction inlet line and with a nonslam check valve and a shutoff valve on the discharge line. On pump sizes over 3 L/second 50 gpm, an automatic recirculating bypass valve unit shall be provided on each pump discharge to prevent the pump from overheating and consequent damage at low flows. Where the automatic recirculating valve is so designed, it may be used as a combination check valve and recirculating valve and the separate nonslam check valve may be omitted.

2.4.10.6 Steam Turbines

****
NOTE: Steam driven boiler auxiliaries will not be used unless the exhaust steam can be used completely. It is recommended that a life cycle cost study be performed to determine if this section is applicable. Reference to steam drives will be deleted if inapplicable for the equipment specified.
****

Steam turbines for boilerfeed pump shall operate the pump properly in a

steam pressure range of [_____] kPa psig with steam back-pressure of [_____] kPa psig. Turbines shall have horizontally-split, two-piece, centerline supported casings, water-cooled bearing cases with ring-oiled, babbitt lined, bronze packed sleeve bearings. Turbines shall also be equipped with a mechanical shaft speed governor and valve, independent over-speed emergency governor and trip valve, reed tachometer, constant pressure type governor, insulation with removable metal jacket, oil-sight glasses with guards, stainless steel steam strainer that is removable without disconnecting piping, any special wrenches and tools required for servicing the turbine, and a sentinel warning on the exhaust casings. Turbines shall conform to NEMA SM 23.

2.4.10.7 Electric Motor Drives

Electric motors shall be selected for continuous duty and nonoverloading characteristics suitable for the power characteristics available. Motors shall be [splashproof] [totally enclosed, nonventilated] [totally enclosed, fan-cooled type] [totally enclosed, fan-cooled type, suitable for installation in a Class II, Division 1, Group F hazardous location in accordance with NFPA 70]. Motor starter shall be magnetic, reduced voltage start type with [general-purpose] [weather-resistant] [water-tight] [dust-tight] [explosion-proof] enclosure.

2.4.10.8 Shop Hydrostatic Testing

All pumps shall be subjected to shop hydrostatic testing. One pump in each service shall be subjected to a complete shop performance test to demonstrate that, at rated capacity, head is within a margin of plus 3 percent and minus 0 percent of design; efficiency is within a tolerance of minus 0 percent; NPSH at the pump's BEP and at the rated condition is within a margin of plus 0 percent and minus 10 percent. Performance tests shall be in accordance with API STD 610. Procedures and results shall be subject to the approval of the Contracting Officer.

2.4.10.9 Control Location

Boiler feedwater pumps shall be started through the combustion equipment/boiler panel, manual/automatic switch.

2.4.11 Condensate Pumps

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NOTE: If inadequate NPSH is available, the designer shall give consideration to substituting either a double suction or positive displacement pump.

****

Condensate pumps shall be horizontal, end-suction, single-stage, centrifugal, motor-driven pumps. Casing shall be of proper material for the pressure involved, and the pumps shall be bronze or Monel trimmed, with stainless steel shafts or shaft sleeves, and bronze impellers. Pumps shall be provided with stuffing boxes. Lubrication shall be by splash oil with oil level sightglass provided. Pumps shall be subject to the same tests specified for the boiler feedpumps. Condensate pumps shall be installed on suitable concrete foundations. Each pump shall have the capacity to pump 100 percent of the design load continuously. Pumps will pump a mixture of condensate and sodium zeolite softened water from the condensate tank to the deaerator. The NPSH required for all pumps shall not exceed [_____] meters feet, and the pumps shall be capable of handling

water up to 99 degrees C 210 degrees F under these conditions without cavitating. Ball bearings amply sized for any and all thrust loads expected shall be water-or oil-cooled and shall be self-aligning. All necessary vents, drains, petcocks, oil sight glasses, etc., and the proper packing materials for mixed condensate and makeup water service shall be of the manufacturer's highest standards. Horizontal pumps shall be factory assembled to the motor drives on a rigid structural steel or cast iron baseplate. Each pump shall be directly connected to a motor through a flexible coupling with approved coupling guards.

2.4.11.1 Design Conditions

The design conditions are:

a. [_____] L/second gpm.

b. [_____] head.

c. Water pumped at 16 to 99 degrees C 60 to 210 degrees F.

2.4.11.2 Condensate Pump Drives

Condensate pump motor drives shall be amply sized to handle the pump power with low discharge heads and shall not exceed 1750 revolutions per minute (rpm). Motors shall be supplied for the power characteristics available and shall be ball bearing and of totally enclosed fan-cooled construction. Condensate pump motors shall be provided with a magnetic across-the-line starter equipped with thermal overload protection. Starters shall be located in the motor control center.

2.4.11.3 Condensate Pump Auxiliaries

Condensate tank and pumps shall be complete with all piping, suction strainers, suction and discharge valves, check valves, and fittings required for an integrated unit. Provisions shall be made in the pump suction and discharge lines for thermal expansion and vibration isolation. Piping shall be factory assembled. All pumps shall be furnished with isolating valves on suction and discharge, suction strainers, startup strainers, silent check valves, and recirculating piping. Pumps shall be arranged with bypass line and orifice in accordance with manufacturer's specifications to recirculate pumped fluid. All controllers, alarms, gauges, sight glasses, control valves, etc., shall be provided with shutoff and/or bypass valves as required for maintenance of the system while in operation.

2.4.12 Emergency Interlock

Emergency interlocks shall be provided to bypass the flue gas or shut down the combustion source, in case of low water, high or low pressure, power failure, or control failure. The system shall act automatically.

2.4.13 Calorimeter

A calorimeter connection shall be provided in the steam main and a flange nozzle shall be provided between the stop gate and the nonreturn valve to permit release to atmosphere when testing the boiler at maximum capacity. The flanged nozzle shall be equipped with blind flange and gaskets.

2.5 CONDENSATE TANK AND ACCESSORIES

2.5.1 Condensate Tank

Condensate tank shall be designed for a working pressure of 103 kPa 15 psig and shall conform to ASME BPVC SEC VIII D1. Tank shall have a storage capacity equal to or greater than indicated and shall be installed complete with all piping and accessories. Condensate tank shall be factory primed with the manufacturer's standard paint.

2.5.2 Feedwater Makeup Valve

A float-controlled valve shall be provided for emergency feedwater makeup to the tank. Valve shall be operated by a float-control mechanism connected to the surge tank and shall maintain a suitable minimum water level in the tank. Float box shall be outside the tank and the connections shall be properly valved to permit blowdown and servicing.

2.5.3 Overflow Trap

An overflow trap designed for the service shall be installed with the condensate tank. The trap shall operate to prevent the water level in the surge tank from rising above a predetermined point by automatically discharging the excess water and shall be designed to prevent the escape of steam and air.

2.5.4 Tank Connection and Controls

Tank shall be provided with all necessary threaded and flanged openings for condensate return, 300 by 400 mm 12 by 16 inch (minimum) access manhole, overflow, drain, pump suction, gauge glass with cocks and drains, and other openings as required. Tank shall be provided with a low-level alarm and pump shutoff and high-level alarm. Alarms shall consist of an alarm horn and warning lights mounted on the control panel as specified.

2.5.5 Design Conditions

The design conditions are:

Tank Capacity (Normal-1/2 capacity)	[_____] liters gallons
Tank Capacity (Design to overflow)	[_____] liters gallons
Condensate Temperature	16 to 99 degrees C60 to 210 degrees F
Tank Operating Pressure	Atmospheric
Tank Outlet Capacity (operating)	[_____] kg lb per hour
Tank Outlet Capacity (design)	[_____] kg lb per hour

2.5.6 Detail Specifications

Tank shall be butt fusion welded steel plate with a maximum diameter of [_____] and a maximum straight side length of [_____]. Tank shall be tested under pressure to assure no leaks. Provisions shall be made in the

tank for all connections. After fabrication, the interior of the tank shall be cleaned of all mill scale, oil, and weld splatter and then coated with a baked-on phenolic lining or approved equivalent material that shall be suitable and guaranteed for continuous immersion in condensate and softened water from a sodium zeolite softener at 99 degrees C 210 degrees F. Condensate tank shall be shop assembled and checked for proper fit of accessories. Vendor shall determine what items should be removed and shipped loose for field assembly. Condensate tank shall be erected in a horizontal position.

2.5.7 Condensate Tank Trim

Condensate tank shall have the following trim:

a. Water gauge glasses with shutoff valves to cover the full water level travel.

b. Thermometer.

c. Makeup water control valve with inlet, outlet, and bypass valves. Mechanical linkage control will not be acceptable.

d. Pneumatic level controller.

e. Level switches with provisions to attach an alarm or 120 volt control signal.

f. Drain valve.

g. Insulation clips for 25 mm 1 inch block insulation.

h. All controllers, alarms, gauges, sight glasses, control valves, etc., shall be provided with shut off and/or bypass valves as required for maintenance of the system while in operation.

2.5.8 Additional Requirements

All required foundations, anchor bolts, concrete work, and grouting shown in the manufacturer's load diagram and anchor bolt plan shall be provided. Insulation and covering shall conform to Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. All wiring incidental to the operation of controls and instrumentation shall be provided. All piping to connect to the tank for accessories shall be provided.

2.6 HEAT EXCHANGERS

****

NOTE: If the bulk of the condensate return is at a high temperature, as from a laundry, a heat exchanger will be used. If the bulk of the condensate is returned to a heating pump unit, a heat exchanger will not be required for that application. Heat exchangers can be used for either heating or cooling the condensate.

****

a. Heat exchangers shall be designed, fabricated, tested, and stamped in accordance with ASME BPVC SEC VIII D1. Additionally, heat exchanger designs shall meet the requirements of HEI 2623. Closed feedwater

heater designs shall meet the requirements of HEI 2622. All heat exchangers shall be provided with relief valves as required by ASME BPVC SEC VIII D1 and HEI 2623 and shall be designed for a working steam pressure of [586] [_____] kPa [85] [_____] psig. [Heat exchangers using service water shall be designed to have the service water inside the tubes.] [The exchangers shall be of straight tube design with bolted full diameter access channel covers to facilitate tube maintenance as required.] Return bonnets are acceptable when there are no tubeside connections at the far end.

b. Materials of construction shall be all carbon steel, except the service water side which shall reflect the service water available. When the water quality permits, the tubes shall be stainless steel in accordance with ASTM A249/A249M, Grade TP 304; the remainder of the tube side shall be all carbon steel. When the service water is known to contain chloride levels harmful to stainless steels, the tubes shall be 90-10 Copper-Nickel in accordance with ASTM B111/B111MAlloy 706; the remainder of the service water side shall be as follows: tubesheets, Monel-clad steel; channel covers, carbon steel lined with Monel; channels and bonnets, Monel.

c. Fixed tubesheet designs are preferred when operating conditions do not impose a large differential movement that cannot be readily accommodated with a simple thin-wall metal bellows expansion joint. For larger differentials, a packed floating tubesheet with lantern ring is acceptable up to 1.03 MPa 150 psig design pressure. For pressures above 1.03 MPa 150 psig, a split-ring floating-head design shall be used.

d. Heat exchangers, steam-to-heat domestic water or other fluids such as glycol-water mixtures or fuel oil shall have the steam in the shell side. The exchangers shall be of U-tube designs with bolted full-diameter channel covers to facilitate tube maintenance as required. The tubesheet shall be the full diameter to match the shell flange and shall have sufficient threaded holes so that a shell hydro test may be applied without the channel in place. Materials of construction shall be all carbon steel with the exception of the tubes which should typically be specified as stainless steel in accordance with ASTM A688/A688M, Grade TP 304, stress relief annealed temper with the U-bends stress relieved after bending. Fuel oil heaters shall have carbon steel tubes in accordance with ASTM A179/A179M and be furnished in the stress relief annealed temper with the U-bends stress relieved after bending.

e. Feedwater heaters shall be of all-welded construction with bolted full diameter channel covers to facilitate tube maintenance as required. The channel barrel shall be integral with the tubesheet and have an internal pass partition bolted cover design that shall be readily removable when the channel cover is removed. Pass partitions that are sealed with a gasketed groove in the channel cover are prohibited. Materials of construction shall be all carbon steel except the tubes. Pressure boundary material shall be in accordance with ASTM A516/A516M, Grade C, when plate material is required, or ASTM A350/A350M when forging material is required. Shroud plate material for desuperheating and subcooling zones shall be in accordance with ASTM A285/A285M, Grade C. Tubes shall be stainless steel in accordance with ASTM A688/A688M, Grade TP 304, stress relief annealed temper with U-bends stress relieved after bending. Shell shall be coated on the outer surfaces with an approved rust-inhibiting paint.

Coils shall be designed for a working pressure of [_____] kPa psig. [A heat exchanger shall also be employed to reduce the temperature of high-pressure condensate by heating domestic or boiler feedwater, to prevent excessive flashing in the condensate tank.]

2.7 DEAERATING FEEDWATER HEATER

Deaerating feedwater heater shall be installed where indicated and shall be the size and capacity indicated. Shell shall be steel plate. [Tray system for a Type I unit shall be corrosion-resistant steel.] Floats shall be of [copper] [corrosion-resistant steel]. Overflow control shall be a [loop seal] [float-controlled overflow trap]. A heater shall be provided with a pressure relief valve, thermometers, pressure gauge, and oil separator. A combination temperature-pressure recorder shall be installed for each feedwater heater. Steam pressure readings shall be taken from the shell, and the temperature bulb shall [indicate] [record] the temperature of the feedwater after it passes over the trays and sprays. An alarm shall be provided to turn on a red pilot signal lamp and to sound a bell in the event that the water level in the feedwater heater storage tank falls to 300 mm 12 inches above the bottom of the tank. System shall be operated by an approved type of external electric float switch connected to the tank. Signal lamp and bell shall be mounted where directed. Float operator for the deaerator level control valve shall be of the externally connected cage type of semisteel construction and noncorrodible float, both designed for 858 kPa 125 psig working pressure, piped with shut-off and drain valves.

2.7.1 Design Conditions

The design conditions are:

Outlet Capacity Design	[_____] kg lb per hour
Outlet Capacity - Operating	[_____] kg lb per hour
Operating Pressure	[_____] kPa psig
Design Pressure	[_____] kPa psig
Storage Tank Capacity	[_____] L gal (Normal Level) at centerline
Operating Temperature	[_____] degrees C F
Pumped Condensate - Operating	[_____] kg/hour at degrees C lb/hour at degrees F liq
Pumped Condensate - Design	[_____] kg/hour at degrees C lb/hour at degrees F liq (min temp)
Makeup steam - Operating	[_____] kg/hour kPa (2.79 MJ/kg) lb/hour psig (1200 Btu/lb)
Makeup steam - Design	[_____] kg/hour kPa (2.79 MJ/kg) lb/hour psig (1200 Btu/lb)

2.7.2 Detail Specifications

****

NOTE: In general, use tray system for fluctuating loads and the spray system for steady loads.

****

Heater shall be spray type with spray valve vent condenser in accordance with ASME BPVC SEC I and shall be designed for [_____] kPa psig working pressure. Deaerator shall be ASME stamped. All steel plate used in construction of the heater and storage tank shells shall be ASTM A285/A285M Grade C. Where thickness makes it desirable, ASTM A515/A515M or ASTM A516/A516M steel may be used as appropriate. At least 2.0 mm 1/16 inch corrosion allowance shall be included over the calculated ASME Code thickness. Heater and storage tank shall be tested at a pressure 50 percent in excess of the design pressure. Heater shall be designed so that corrosive gases do not come in contact with the outer shell or heads of the unit. However, units not complying with this provision will be accepted providing the upper head and the heater shell sections in contact with gases are clad with 304 stainless steel, 2.0 mm 1/16 inch minimum thickness. Heater shall be provided with adequate supports, manholes, gauge glasses denoting full water travel in the storage section, and all other connections as necessary for a complete working unit, along with those called out as accessories. Heater shall be provided with an internal vent condenser fabricated entirely of stainless steel which shall include a vent hood and vent orifice or separate vent valve. Heater section shall contain spring-loaded spray valves mounted in a stainless steel water box and a stainless steel vent condenser. Spray valves shall be constructed of 18/8 stainless steel and provide a constant angle of spray at ranges from 10 to 150 percent of capacity. Valves shall be hydraulically balanced, thus requiring no guides that might bind, scale, or otherwise clog. Spray valves shall be located to allow their servicing, inspection, and removal. Maximum tank dimensions shall be [_____] outside diameter. Internal parts of the deaerating heater, including baffles, distributing nozzles, vent pipe, and vent collecting hood shall be constructed of heavy gauge stainless steel. A drawing showing the "internal" construction of the heater shall accompany each bid. Deaerator shall include an internal sparger tube for chemical treatment injection. Boiler feedwater pump suction nozzle shall include a vortex breaker. Deaerator shall be provided with all of the connections shown on the drawings, as a minimum.

2.7.3 Deaerator Trim

Deaerator shall be provided with the following trim:

a. Safety relief valve set to open at 83 kPa 12 psig, and of sufficient capacity to protect the deaerator from excessive steam pressure with the steam regulating valve in fully open position.

b. Vacuum breaker valve.

c. Water gauge glasses with shutoff valves to cover the full water level range.

d. Pressure gauges shall conform to ASME B40.100 and shall be complete with siphon and isolation valve.

e. Makeup steam control valve with strainer, bypass, inlet and outlet valves. Valves to reduce steam pressure from [_____] kPa psig to [_____] kPa psig, with capability to operate at up to [2.07] [3.45] MPa [300] [500] psig inlet pressure. Reducing valve shall be adjusted to maintain the desired terminal pressure, regardless of fluctuations in the initial pressure. Valves shall be single-seated, spring loaded,

quiet in operation, and guaranteed not to stick. Valve body 65 mm 2-1/2 inches and larger shall be cast steel; 50 mm 2 inches and smaller shall be of bronze. Valve trim shall be stainless steel, Monel metal, or approved corrosion-resisting material. All parts subject to wear shall be readily replaceable. Valves shall have seats and plugs faced with cobalt tungsten carbide mixture, or be made of heat treated stainless steel or high chromium steel guaranteed to resist erosion. Seat and plug facing shall have a Brinell hardness of not less than 450. Valve shall be installed with a strainer, a bypass, [safety valve on deaerator] as indicated. Sensing line shall be connected to the steam space in the deaerator. Control valve shall be sized for a minimum capacity of [_____] kg/hour lb/hour at design conditions, but shall not have a capacity greater than [_____] kg/hour lb/hour for the same conditions. Valve trim shall be selected to result in a noise level not to exceed 85 dBA, measured 914 mm 3 feet from valve.

f. Makeup water control valve with bypass and inlet and outlet valves. Valve to operate at an inlet pressure of up to 552 kPa 80 psig.

g. Pneumatic level controller. Mechanical linkage control of makeup will not be acceptable.

h. Overflow trap or valve with float control.

i. Insulation clips for 38 mm 1-1/2 inch block insulation.

j. Lifting lugs as required.

k. Multiport relief valve with exhaust head for mounting in piping supplied by others.

l. Manual air vent valve.

m. Drain valve.

n. Chemical injection valve.

o. Sample valve.

p. High and low level switches.

q. All support steel.

2.7.4 Additional Requirements

All required foundations, anchor bolts, concrete work, and grouting, will be in accordance with Manufacturer's Load Diagram and Anchor Bolt Plan. Installation and covering shall conform to Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. All wiring incidental to the operation of controls and instrumentation will be provided. All steam and water piping to connect to the deaerator will be provided. Testing outfit conforming to ASTM D888 shall be provided, complete with chemicals for 100 tests. All controllers, alarms, gauges, sight glass, control valves, etc., shall be provided with shutoff and/or bypass valves as required for maintenance of the system while in operation.

2.7.5 Performance Guarantee

The manufacturer's guarantee shall provide that the deaerator shall:

a. Be of sufficient design to reduce the oxygen content of the feedwater to [_____] cc/liter when tested by the accepted modified Winkler or ASTM method.

b. Be of sufficient design to reduce free carbon dioxide to zero.

c. Be of sufficient design to ensure essentially noiseless operation at all rates up to and including maximum capacity.

d. Meet all performance requirements at all loads from 3 to 100 percent of capacity.

e. Admit makeup water only after giving preference to available condensate.

2.8 PIPING

Unless otherwise specified, pipe and fittings shall conform to Section 33 63 23 EXTERIOR ABOVEGROUND STEAM DISTRIBUTION.

2.9 CHEMICAL TREATMENT AND WATER SOFTENING EQUIPMENT

2.9.1 Chemical Feeder

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NOTE: Chemical feeder shall conform to requirements of UFC 3-410-01 or UFC 3-410-02.
****

A feeder unit shall be provided for each boiler. Chemical feeders shall be automatic proportioning, shot, or pump type. All appurtenances necessary for satisfactory operation shall be provided. Size and capacity of feeder shall be based upon local requirements and water analysis. Feed piping shall be installed to feed chemicals directly to each boiler, as shown on the drawings or as required for the equipment supplied.

2.9.2 Pumps and Tanks

Chemical feed pumps and tanks shall be furnished as a package with the pumps mounted on and piping connected to the tank. Pump cylinders, plungers, ball check valves, and check valve bodies shall be of corrosion-resistant materials suitable for the chemicals being pumped. Volumetric accuracy of the pumps shall be within one percent over the range indicated. Pump capacities shall be adjustable by positioning the crankpin with micrometer setscrews. Stroke length scale shall be divided in percentage graduations engraved on the scale. Cylinders shall be replaceable for increased or reduced pressure or capacity ranges. Drive motors shall be suitable for the electric power available and shall have drip-proof enclosures. Each pump shall be driven by a separate motor. Tanks shall be made of polypropylene and mounted on legs. Tanks shall have filling and drain connections, and gauge glass. Each tank shall be furnished with one pump, mounted and piped with black iron pipe and fittings, with suction strainer and stainless steel screen, and with 13 mm 1/2 inch relief valve with steel body and stainless steel trim. Each tank shall have a hinged cover. Tank bottom shall be dished concave to a

radius equal to the diameter of the tank. Units shall be for phosphate or caustic feed and sulfate feeding. Motor-driven agitator shall be provided. The pump shall be designed to feed the chemical solutions into the boiler feedwater system.

2.9.3 Water Softening Equipment

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NOTE: Need for softening equipment for makeup water will be as determined in accordance with UFC 3-410-01 or UFC 3-410-02. If water softening is not required, delete the paragraph.

****

A complete sodium zeolite cycle water softening system shall be provided as specified in Section 22 31 00 WATER SOFTENERS, CATION-EXCHANGE (SODIUM CYCLE). Equipment shall be sized to run 24 hours before regeneration when operating at a sustained softening rate of [_____] L/second gpm. Tanks shall be complete with cover and designed to eliminate the need for a gravel supporting bed.

2.10 BOILER CONTROL EQUIPMENT

****

NOTE: Positioning type control equipment will be specified for boilers with capacities of 13 MW 45 MBtuh or less. Metering type equipment will be used for larger boilers. Positioning type controls may be furnished for boilers with capacity of 13 MW 45 MBtuh or more in lieu of metering type.

A continuous emmissions monitoring system (CEMS) is required by the Clean Air Act Amendment (CAAA) of 1990 if the fuel utilized is oil or coal and the heat input is 3 MW 10 million BTU/HR or greater. A CEMS may also be required by state or local laws. If a CEMS is necessary the designer should review the CAAA and the relevant state or local law early in the project to allow time to incorporate the requires CEMS specifications and to determine which flue gas emmissions will be included in the required reports.

****

a. An automatic control system shall be installed for each boiler in accordance with the manufacturer's recommendations. All locally indicating instrumentation and controls shall be provided and installed complete, as required to suit equipment furnished and as shown. All remote instrumentation, controls, and their connection points will also be provided and installed as indicated. If the controls are manufactured by a manufacturer other than the boiler manufacturer, installation of the controls shall be in accordance with the control manufacturer's instructions. Automatic controllers shall be located on the control room panel as specified.

b. Equipment shall operate either pneumatically, electrically, or electronically. Pneumatic control systems shall conform to CAGI B19.1. Air filter regulator sets shall be installed at each control valve and transmitter in the system. Master air filter regulator set on the

control panel shall be of the dual type where one side can be cleaned and repaired while the other is in operation. Exterior control air piping and devices shall be protected from freezing by use of a regenerative desiccant dryer. Each system shall be provided with a selector switch or other means to permit manual control of the firing rate when required. Electrical control devices shall be rated at 120 volts and shall be connected as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Operating and limit controls shall be wired to interrupt the ungrounded circuit conductor.

c.[Steam and energy generating equipment shall include instrumentation and sufficient metering for accountability interface with a future Energy Monitoring and Control System (EMCS).] If pneumatic controls are provided, duplex air compressors with a drier between the compressors and tank shall be provided. Air compressor units shall be sized to run not more than 60 percent of the time when all controls are in service.

2.10.1 Positioning Type

Positioning type control equipment shall be capable of maintaining boiler steam pressure within plus or minus 2 percent of the set pressure over the complete range of boiler operation. Set point controllers may be used for on/off functions only. Combustion efficiency shall be maintained without appreciable manual adjustment. System shall be capable of maintaining the specified pressure provided that the load does not exceed a 15 percent per minute change in capacity at any one time. Master transmitter shall be connected to the main steam header where the steam pressure is to be controlled. The signal transmitted from this point to the master controller shall be a function of steam pressure. On multiple boiler installations, a means shall be provided to base load on individual boilers while on automatic, and each boiler unit shall be individually controlled. Provision shall be made on the control system for adding on other boilers to the system with only minor wiring or piping changes on the panel. Each automatic controller shall have a manual-to-automatic station and indicator on the control panel that will provide for selecting either automatic control or manual control and also will provide for manual operation. Manual controls shall be arranged to allow any one or more of the functions of the control system to be controlled manually while the other functions remain on automatic control. The manual control station shall be complete with all necessary indicators to facilitate changing from automatic control to manual control and vice versa. Controllers mounted on the instrument panel shall indicate and control measurement in the areas shown, and shall have a manual adjustment on the front of the instrument. Controllers shall be installed complete with wiring or piping between the controller, transmitter, and the final control device.

2.10.2 Equipment

Control equipment and instruments shall include fan controls, time clocks, relays, operating switches, indicating lights, gauges, motor starters, fuses, alarms, and circuit elements of the control system, and other controls and instruments necessary for unit operation. Control system shall be in accordance with FM APP GUIDE. Operating controls and instruments shall be mounted on one or more free-standing control panels conveniently located and placed so that operating personnel may effectively monitor boiler operations but not in a position that would interfere with those operations. Indicating and recording instruments

will be provided for pressure, flow of air and liquids, and alarm circuitry. Automatic-control circuit systems and manual switches shall be interlocked to prevent hazardous conditions or the discharge of excessive amounts of air pollutants.

2.10.3 Boiler System Operation

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NOTE: If the fuel being burned contains any significant pollutants, some states may not allow the flue gases to be vented to the atmosphere without going through an air pollution control device.

****

When steam is demanded, gases shall be directed through the boiler. As long as maximum energy is required, this shall be the mode of operation. If less than full energy production is required, gas flow shall be modulated to reduce steam production by the boiler. Specified steam pressure shall be maintained within plus or minus 1 pound by means of a pressurestat and a boiler-draft regulator. The pressurestat with necessary relays shall stop and start the flow of gases by means of the induced draft fan so as to maintain the desired steam pressure.

2.10.4 Damper Control

Power units for the movement of dampers shall be sized to operate the device to be positioned, and shall be mounted so that a rigid mechanical connection to the device being operated can be used. Units shall automatically close in the event of failure of the operating medium. Manual operation of the controller shall not necessitate disconnecting the linkages during power failure or other emergency. Position switches shall be included on fuel and air-drive units for interlock with safety systems. Retransmitting devices shall be placed on all power units for remote indication on the control panel of the position of the mechanism at any time. If electric operators are utilized, gear trains on the units shall be oil immersed.

2.10.5 Draft Fan Control

Induced draft centrifugal fans shall have outlet dampers [and variable speed control]. [Axial propeller fans shall have variable propeller pitch control.] Means shall be provided for operating the induced draft fan for 15 minutes after the combustion equipment has ceased operation.

2.10.6 Soot Blower

All controls, lights, switches, and indicators provided for operation of soot blower shall be mounted on the control cabinet.

2.10.7 Boiler Limit Controls

Limit controls and interlock switches shall conform to UL 353.

2.10.7.1 Low-Water Cutoffs

Two low-water cutoffs shall be provided to prevent startup and to shut down the combustion equipment if the boiler water level is below the preset safe level. Primary interlock may be automatic or manual reset

type. Secondary interlock shall be the manual reset type.

2.10.7.2 High-Pressure Limit Switch

A high-pressure limit switch shall be provided to shut down the combustion equipment when steam pressure exceeds the preset safe limit. This equipment shall be additional to the operating controls.

2.10.7.3 Draft Loss Interlock

A draft loss interlock and an airflow switch or a suction switch shall be provided to prevent startup and to shut down or bypass the combustion equipment when air is inadequate to safely support combustion. Limit and operating controls shall be provided for operation on a two-wire grounded branch circuit.

2.10.8 Instrument Control Panel

Panel shall be a NEMA ICS 6 Type 4 unit prewired, of steel, weathertight, and conforming to UL 50. Unless enclosed in a booth or separate room, the panel shall also be constructed to protect the instruments and controls from dust. The boiler control panel shall be located next to the control panel for the combustion equipment, or one panel may be used for both. Wiring of all instrument connectors and cable termination connectors shall be done in the factory by the instrumentation fabricator. All controls, instruments, and other equipment shall be flush mounted at the factory and be assembly-tested before shipment. A lock and two keys shall be furnished. All controls and instruments shall be identified with nameplates. [A thermostatically controlled heater to prevent condensation shall be provided.]

2.10.8.1 Panel Details

a. Instrument and control panel shall be sized to contain all controls, instruments, gauges, and meters. Panels shall be freestanding with a faceplate of not less than 7 mm 3/16 inch steel, properly reinforced, and shall be finished with the manufacturer's standard finish coating. The units shall be mounted flush on the panel as far as practicable. All controls, instruments, and other equipment shall be flush mounted, each fitting neatly into a cutout, and completely covering the cutout and any mounting screws or bolts.

b. Back of the panel shall be enclosed with sheet metal and with adequate removable access panels or doors for maintenance and removal of any unit without interfering with other units. Proper latching equipment and hardware shall be provided. Each recorder, indicator, and control unit shall be identified with nameplates securely fastened to the panel. Nameplates shall be black over white laminated plastic with the lettering penetrating the black surface to expose the white. Panel shall have continuous rapid-start fluorescent light fixtures mounted with reflectors providing suitable shielding to illuminate all controls, instruments, gauges, and meters.

c. All field piping connections shall terminate in one bulkhead-mounted manifold, located to conform with the installation requirements of the system. All field electrical wiring shall terminate in a color-coded terminal strip to conform with the installation requirements of the system. All electrical tubing or piping connections to controls, instruments, or other devices on the panel shall be inside the panel

and not visible from the panel front. A suitable plug-in strip shall be provided in the rear of the panel for any required plug-in electrical connections of the instruments. All necessary transformers, separate relays, switches, and fuses shall be installed in a fully enclosed junction box. A fused safety switch shall serve the 120-volt power supply required for control circuits.

d. If a pneumatic control system is provided, the panel shall include duplex air supply filter and regulator set mounted on the rear of the panel with properly identified pneumatic terminal blocks and low point drain. High pressure lines will not be allowed to enter the panel. [If packaged burner units with integral controls are furnished, the control equipment may be mounted on a separate panel for each unit. Controllers and indicators specified or required shall be panel mounted and tested at the factory complete with relays, transformers, switches, wiring, valves, piping, and other appurtenances. All wiring and piping within the panel shall be color-coded or otherwise identified.] Thermocouple and low energy signal conductors shall be completely isolated from power and alarm conductors, subject to approval by the Contracting Officer. Visual and audible alarms shall be provided to protect personnel and equipment.

2.10.8.2 Recorders

Recorders shall be servo-mechanism type, or multiple-pen type. [Circular] [Strip] chart shall be provided. Minimum chart width is 100 mm 4 inches. Accuracy shall be plus or minus 1/2 percent. Each pen shall have a separate scale calibrated in engineering units. Chart drive shall be 120 volts ac. One year's supply of chart paper shall be provided. The record shall be made in ink on a [24-hour] [31-day] chart driven by an electric clock mechanism. Each recorder point shall be made with a different color ink. Recorders shall be installed complete with all necessary wiring or pipe between the recorder and the transmitter in the boiler room. Recorders mounted on the instrument panel shall record and indicate measurement in the areas shown.

2.10.8.3 Panel Display

The panel shall include visual indication of the various modes of the main system components (i.e., damper positions, I.D. fans). As a minimum, the following parameters shall be displayed on the panel:

a. Temperature recorder (boiler inlet exit).

b. Steam flow and pressure recorder (pressure immediately after second block valve, steam flow totalizer).

c. Clock with minimum 200 mm 8 inch diameter face (one panel only).

d. Steam gauge conforming to ASME B40.100 to indicate boiler shell or drum pressure.

2.10.8.4 Identification

All field items shall be furnished with a permanent metal tag suitable for tag number or service identification; back of panel items shall be included in this category. Wires and cables shall be installed without joints or splices except at terminal points. Wires shall be identified at both ends by labels.

2.10.8.5 System Diagram

Laminated, color-coded system diagram mounted on the control panel indicating all system components and location of all sensors and alarm points shall be furnished.

2.10.9 Pilot Lights

Pilot lights shall be assembled in a factory-built cabinet, suitable for flush mounting in cutouts in the control cabinet, complete with extruded trim, clamps, and sheet metal rear housing, and finished in baked black enamel. Components shall be integrated through appropriate electro-mechanical devices with push-to-test indicating lights. Industrial oil-tight construction shall be provided in the following colors for the indication functions:

a. Amber for power on the system.

b. Green for boiler purge completion (one per boiler).

c. White or manufacturer's standard color for energizing main fuel valves.

d. Red for alarms.

(1) High temperature in combustion chamber.

(2) High temperature at induced draft fan inlet.

(3) System operation.

(4) Emergency damper closed.

2.10.10 Clock

Clock shall be electric synchronous motor type. The clock shall be for surface mounting and suitable for operation on 115-volt, 60-Hz single-phase electric service. The clock shall have a shatterproof, crystal-covered white dial, easy-to-read black Arabic numerals, black hour and minute hands, red sweep second hand, and external manual reset knob at bottom of case. The motor gear train shall be sealed in a permanent oil bath.

2.10.11 Alarm Annunciator Panel

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NOTE: Edit to indicate the number of points desired and specific items in the list.

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An annunciator system shall be mounted on each control panel. Visual signals shall be backlighted nameplates for each point. A common audible alarm signal and a common acknowledge push button shall be provided for each control panel. A common alarm-silencing relay shall be included in the alarm circuit which will permit the boiler operator to silence the audible horn while retaining visual indication until the malfunction or abnormal condition has been cleared. Nameplate size of alarm modules shall be nominal 70 mm 2-3/4 inches high by 75 mm 3 inches wide in translucent white acrylic plexiglass and all nomenclature shall be

engraved on front surface in black lettering. Flasher module shall be mounted and prewired with silence and test pushbuttons. Alarm points and window engraving shall be as shown below.

ALARM POINT	WINDOW ENGRAVING
LSL-[_____]	High condensate tank level
LSL-[_____]	Level low, condensate storage tank
LSL-[_____]	Pump cut-out, condensate storage tank
PSL-[_____]	Pressure-low condensate
PSL-[_____]	Pressure-low feedwater
PSH-[_____]	Pressure-high steam drum
LSH-[_____]	Level-high steam drum
LSL-[_____]	Low water level with cutoff
LSL-[_____]	Second low water level cutoff
LSH-[_____]	Level-high deaerator
LSL-[_____]	Level-low, deaerator
PSL-[_____]	Induced draft fan failure
PSL-[_____]	Boiler tube cleaning failure

2.10.12 Steam Flowmeters

Steam flowmeters shall be provided to measure the steam flow from each boiler and each main steam header outlet. Flow meters shall also be provided to measure feedwater flow to each boiler. Nozzles and orifice plates shall be flange-mounting type and made of stainless steel. Orifice plates shall be of the square edge, concentric, paddle type designed for flange taps. Condensate pots shall be provided for steam service. Meters shall be designed to accurately measure saturated steam at a gauge pressure of [_____] kPa psi. Meters shall be direct connected and of the indicating, recording, and integrating type with electric chart drives. Instrument cases shall be dust-tight metallic or plastic, finished in manufacturer's standard black, and arranged for flush-panel mounting. Flow records shall be in thousands of kg pounds per hour on an ink chart recorder. Steam flow shall be totalized in kg pounds by an integrator having not less than a six-digit counter. The installation of stainless steel orifice plates shall include shutoff valves, equalizing valves, and blowdown valves. Each meter shall have a guaranteed accuracy of plus or minus 1/2 of 1 percent while operating at 20 to 100 percent of capacity. Steam-flow orifices and associated steam piping shall be installed in accordance with the manufacturer's recommendations and labeled with the following tags:

Tag Number	Service
FR-[_____]	Unit Number 1, Steam Flow
FR-[_____]	Unit Number 2, Steam Flow
FR-[_____]	Unit Number 3, Steam Flow
[FR-[_____]]	[Export Steam, Steam Flow]
[FR-[_____]]	[Domestic Steam, Steam Flow]

2.10.12.1 Orifice Plate

The orifice plate shall be sized to produce a 25.42 kPa 100 inch W.G. pressure differential at the rated flow of the meter as shown on the drawings. Orifice plates shall be 3.2 mm 1/8 inch thick 316 or 304 SS, chambered with the sharp edge orifice facing upstream, fitted with a tab extending beyond flanges showing bore size, differential, and maximum flow. Calculation of flow shall be made by the manufacturer under ASME MFC-3M, or equivalent by Spink or American Gas Association. Plates for steam or condensibles service shall have a weep hole drilled in them when installed in horizontal meter runs.

2.10.12.2 Flow Transmitters

Pressure differential and transmitting components shall have an accuracy of plus or minus 1 percent, 0.15 percent repeatability, 4-20 milliamp dc signal into 0-500 ohms, (if electronic) internal square root extractor, adjustable zero and span, and equalizing valves. Span range, and working pressure shall be as shown on the drawings. Transmitters shall be installed with condensate reservoirs where required to protect transmitter from excessive temperature.

2.10.13 Boiler Feedwater Flow Meters

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NOTE: For boilers having less than 4500 kg/hour 10,000 lb/hour steaming capacity, a mechanical feedwater meter may be provided. Plants having metered zeolite softeners used exclusively for boiler makeup will not require an additional cold water makeup water meter. Boilers over 4500 kg/hour 10,000 lb/hour capacity will have indicating-recording meters and they will be integrating type where indicated.

****

Flow meters for boiler feedwater measurement shall be Differential Pressure Type, Venturi Style. Venturi flow tubes shall be pound-rated with a series of nozzles around the inner surface to sense and average the velocity head. Tubes 150 mm 6 inches and larger shall be flanged and smaller tubes shall be installed between welded neck flanges. Smaller flow tubes shall be corrosion-resistant steel and flanged tubes shall have corrosion-resistant steel throat inserts. Metering shall be for water flow [and feedwater temperature]. The receiver for each boiler shall be

mounted on the boiler instrument panel. Equipment shall be complete with differential pressure transmitter, shutoff valves, equalizing valves, and blowdown valves as required for a complete installation.

2.10.13.1 Indicating Feedwater Meter Receivers

Meter receivers shall match other panel components in appearance and shall indicate water flow in [_____]. Where indicating feedwater meter only is utilized, a companion indicating feedwater temperature receiver shall be provided.

2.10.13.2 Indicating, Recording, and Integrating Receivers

Meter receivers shall be indicating, recording, [and integrating] furnished in a dust-tight metallic or plastic case finished in manufacturer's standard black finish and arranged for flush panel mounting. The indicator shall show with a pointer the rate of water flow. The record of flow, in thousands of kg pounds per hour, shall be made in ink on a 24 hour, 300 mm 12 inch diameter, equally graduated circular chart driven by an electric clock mechanism. Sufficient blank charts and ink shall be provided for 400 days of operation. Meter shall also record boiler feedwater temperature in degrees C and degrees F degrees F on the same chart. [Water shall be totalized in kg pounds by an integrator having not less than a six-digit counter.]

2.10.14 Blowoff Sample Cooler

Sample cooler shall be a water-cooled, shell-and-tube or shell-and-coil type heat exchanger with stainless steel tubes and cast-iron or steel shell suitable for cooling the blowoff before sampling. Cooler shall be connected to a header and valved so the operator can obtain a sample of properly cooled blowoff from any boiler as desired. Cooler shall be properly supported and shall have a brass or bronze sampling cock with lever or compression handle. A sampling glass container suitable for handling the water temperature to be encountered and a hydrometer or equivalent device suitable for measuring the concentration of solids in the water and reading in parts per million shall be provided.

2.10.15 Temperature Indicators

The Contractor may install any of the following temperature measuring devices as indicated. Gauges shall match pressure gauges in appearance and shall match requirements of the transmitters supplied. Remote temperature indicators shall include condensate and steam temperature.

2.10.15.1 Thermometers

Thermometers shall conform to ASME PTC 19.3 TW, Type 1, Class 3, dial with wells and separable corrosion-resistant steel sockets, and temperature range suitable for the use encountered. Mercury shall not be used in thermometers. Thermometer shall be a dial, 90 mm 3-1/2 inch diameter chromium-plated case, remote bulb or direct bulb as required, with plus or minus 1 degree C 2 degree F accuracy, and white face with black digits graduated in 2 degree increments. Thermometers shall be installed so as to be easily read from the operating floor.

2.10.15.2 Thermocouples

Thermocouples shall be suitable for continuous operation and control at

temperatures up to 1260 degrees C 2300 degrees F, accurate to 0.75 percent, and shall be long enough to be inserted 150 mm 6 inches into the boiler. Thermocouples conforming to ASTM E230/E230M, Type K shall be provided with an adjustable flange and with a high-temperature metal alloy closed-end protection tube suitable for inserting into the furnace without support of the projecting end. One hundred feet of 16-gauge compensating lead wire with a weatherproof braid shall be supplied for connecting the thermocouple to the instrument. Installed unit shall indicate gas passage temperatures and shall control combustion equipment operation. Temperature shall be transmitted to the instrument in the control panel as shown.

2.10.15.3 Indicating, Recording Pyrometers

The instrument shall have a temperature range from minus 18 to plus 1316 degrees C 0 to 2400 degrees F, and shall be accurate to within plus or minus 1/4 of 1 percent of the range. Temperature shall be indicated on a large scale with prominent black letters on a white background and shall be recorded by chart recorder. The instrument shall have automatic cold-junction compensation. A simple means of pyrometer standardization shall be provided. Instrument shall not be affected by vibration, dust, or air currents when the door of the instrument is open. Lighting circuit for 110 volts ac shall be available.

2.10.16 Draft Indicator and Control

An indicator continuously showing pressure in the boiler shall be provided. A separate draft-controlling instrument maintaining a constant balanced (atmospheric) pressure in the boiler shall also be provided. Gauges shall conform to ASME B40.100, Style 1 with a diaphragm or bellows actuating system and a circular scale. Gauges shall have a zero adjustment screw and a connection to atmosphere. Suitable shutoff cocks shall be provided. Gauges shall be remote reading to the control panel and shall be installed complete with all necessary piping between the gauges and the points at which the drafts are measured. Gauge piping shall be copper tubing conforming to ASTM B68/B68M, Type K or L.

2.10.17 Pressure Gauges

Gauges shall be heavy-duty industrial type conforming to ASME B40.100, Type I, Class 1 or 2, as applicable, style as required, suitable for specified pressure or vacuum with minimum 115 mm 4-1/2 inch diameter dial, except as otherwise specified. Pressure gauges shall be installed on the low-pressure side of each pressure-reducing valve, on the suction and discharge side of each pump, on inlets and outlets of heat exchangers, on the feedwater heater, and where shown or required for proper operation. Pressure gauge shall be installed on each boiler and shall have a [250 mm 10 inch] [300 mm 12 inch] dial face. Gauges shall be installed so as to be accessible and easily read from the operating floor. Gauges shall be equipped with integral or separate siphons, and pulsation dampeners and shall be connected by brass pipe and fittings with shutoff cocks. Where pressure reducing valves are used, upstream and downstream gauges shall be placed close to the pressure reducing assembly, but connected approximately 3 m 10 feettherefrom. Operating ranges of the gauges shall be approximately twice the normal operating pressure.

2.10.17.1 Pressure Gauges (Panel)

[Three] [_____] 150 mm 6 inch dial size, phenol or brass, black enamel

finished case, gauges shall be furnished and installed to indicate main steam, boiler feedwater, and deaerator makeup. Gauges shall be Bourdon tube style with back connections and white dials with black lettering. Steam gauges shall be equipped with siphons and all gauges shall have shutoff valves at the panel. Panel entry shall be through bulk-head connectors located in the upper part of the panel. Gauge accuracy shall be at least 1/2 of 1 percent and normal readings shall be approximately 50 to 75 percent of full scale reading. The gauges shall be labeled:

Tag Number	Service	Pressure Range, kPa psig
PI-[_____]	Condensate, Supply Pressure	-69 to 345 -10 to 50
PI-[_____]	Feedwater, Supply Pressure	0 to 2068 0 to 300
PI-[_____]	Main Steam, Steam Pressure	0 to 2068 0 to 300

2.10.17.2 Pressure Gauges (Local)

[_____] 115 mm 4-1/2 inch dial size, phenol or brass, black enamel finished case, gauges shall be furnished and installed for the services shown below. Gauges shall be Bourdon-tube style with bottom connections and white dials with black lettering. Steam gauges shall be equipped with siphons and all shall be installed with shutoff valves. Gauge accuracy shall be at least 1/2 of 1 percent and normal readings shall be approximately 50 to 75 percent of full scale reading.

Tag Number	Service
PI-[_____]	Condensate Pump Number 1, Discharge Pressure
PI-[_____]	Condensate Pump Number 2, Discharge Pressure
PI-[_____]	Potable Water Supply Pressure
PI-[_____]	B.F. Pump Number 1, Suction Pressure
PI-[_____]	B.F. Pump Number 1, Discharge Pressure
PI-[_____]	B.F. Pump Number 2, Suction Pressure
PI-[_____]	B.F. Pump Number 2, Discharge Pressure
PI-[_____]	Main Steam, Steam Pressure
PI-[_____]	B.F. Pumps, Strainer Pressure
PI-[_____]	Condensate Pump No. 1, Suction Pressure
PI-[_____]	Condensate Pump No. 2, Suction Pressure

Gauges shall conform to ASME B40.100 and shall be of pressure detecting class, single, Bourdon tube style, suitable for detecting air pressure. Gauges shall be remote reading to the control panel.

2.10.18 Feedwater Temperature and Pressure Recorder

Feedwater temperature and pressure recorder shall be installed on the boiler plant central metering panel to record the deaerated feedwater temperature and the pressure of steam space in the deaerating heater. Recorder shall be as specified. Unit shall be provided with interconnecting tubing and separable sockets for elements located in the feedwater heater. Electrical connections shall be totally enclosed. Accuracy shall be within plus or minus 1 percent of the chart range.

2.10.19 Condensate Flowmeter

A 40 mm 1-1/2 inch in-line disk meter shall be furnished and installed in the makeup line to the deaerator. Meter shall have a bronze housing, stainless steel trim, and disk suitable for an operating temperature of 105 degrees C 220 degrees F. Meter shall be equipped with a register of at least six digits and have a capacity of at least 3 L/second 50 gallons per minute.

Tag Number	Service
FQI-[_____]	Condensate Flow

2.11 TOOLS

Special tools only shall be furnished and shall include all uncommon tools necessary for the operation, cleanout, and maintenance of the boilers, pumps, fans, controls, meters, special piping systems, and other auxiliary equipment. Small hand tools shall be furnished with a suitable cabinet, mounted where directed. The following tools shall also be furnished.

2.11.1 Tube Cleaner

For water-tube boiler installations, a water-driven cleaner shall be provided with three rotary cutters, the necessary length of armored water hose, valves, and all other appurtenances necessary for operation. Tube cleaner shall be provided for each size of watertube in the boiler, with one extra set of cutters for each size cleaner. Necessary valves and fittings shall be provided to permit convenient connection of the cleaner hose to one of the boiler feed pumps to supply cold raw water for operation of the cleaner. Piping arrangement shall be such that one boiler feed pump may be used to operate the cleaner without interfering with normal operation.

2.11.2 Tube Brush

Tube brush (for fire-tube boiler installations), with steel bristles and jointed handle of sufficient length to clean full length of fire-tubes, shall be provided.

2.11.3 Smoke Pipe Cleaner

Cleaner shall be provided to clean the breaching and smoke connections. Cleaner shall have jointed handle of sufficient length to clean breeching and smoke connections without dismantling.

2.11.4 Wrenches and Gaskets

Wrenches shall be provided as required for opening boiler manholes, handholes, and cleanouts. One set of extra gaskets shall be provided for all boiler manholes and handholes, for pump barrels, and other similar items of equipment. All gaskets shall be packaged and properly identified.

2.12 PAINTING AND FINISHING

2.12.1 Preventing Corrosion

Unless otherwise specified, surfaces of ferrous metal subject to corrosion shall be factory painted in accordance with the manufacturer's standard practice. All exposed pipe covering shall be painted as specified in Section 09 90 00 PAINTS AND COATINGS. Aluminum sheath over insulation shall not be painted. All metallic materials shall be protected against corrosion. Where connected to dissimilar metal, aluminum shall be protected by approved fittings and treatment. All parts such as boxes, bodies, fittings, guards, etc., made of ferrous metals, but not of corrosion-resistant steel, shall be zinc coated in accordance with ASTM A123/A123M or ASTM A153/A153M, except where other equivalent protective treatment is specifically approved in writing by the Contracting Officer. Where a rust-inhibiting coating or hot-dip galvanizing is specified, any protective treatment system that will pass the salt-spray fog test is acceptable.

2.12.2 Treatment

All surfaces of castings, forgings, molded parts, stampings, welded parts, exterior surfaces of the boiler, before application of the insulation, and all interior surfaces of the sheet jacket, before assembly, shall be cleaned to bare metal to remove oil, rust, sand, dirt, fins, spurs, scale, slag, flux, etc., before primer is applied at the factory. External surfaces shall be smooth and all edges shall be rounded or beveled, unless sharpness is required to perform a necessary function.

2.12.3 Boiler Coating

Boiler shall be finished with one coat of silicone aluminum heat-resisting (up to 648 degrees C 1200 degrees F) paint. Paint shall be applied directly to clean bare metal surfaces and shall attain a minimum dry film thickness of 1 mil. After assembly, all exposed surfaces of the equipment normally painted in good commercial practice shall be cleaned to bare metal and finished with two coats of silicone aluminum heat-resisting paint, with each coat being a minimum dry film thickness of 0.025 mm 1 mil. Component parts procured factory finished need not be repainted. Mechanical cleaning need not be performed on the sheet steel jacket if the surfaces are free of all mill scale and rust. However, the surfaces shall be cleaned to remove all grease and other foreign matter. Paint shall not be applied when the temperature is below 10 degrees C 50 degrees F or above 32 degrees C 90 degrees F.

2.12.4 Equipment Coating

Equipment and component items, when fabricated from ferrous metal, shall be factory finished with the manufacturer's standard finish if located within buildings. Items located outside shall have weather-resistant finishes that will withstand 500 hours of exposure to the salt-spray test specified in ASTM B117, using a 20 percent sodium chloride solution. This

test may be performed on test specimens coated and finished in the same manner as the actual equipment. Immediately after the test, the specimens shall show no sign of blistering, wrinkling, cracking, or loss of adhesion and no sign of rust beyond 3 mm 1/8 inch on either side of the scratch mark.

2.13 FACTORY TESTS

Initial capacity and performance tests of factory-assembled boiler components shall be conducted at the manufacturer's plant. Any material or equipment rejected shall be either repaired or replaced before installation.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancies before performing the work. Because of the small scale of the drawings, it is not possible to detail all runs and indicate all required offsets, fittings, and accessories. Investigate structural and finish conditions affecting the work, arrange the work accordingly as required, and furnish the fittings and accessories required to meet such conditions. The plans are generally diagrammatic and the work of the different trades shall be coordinated so interference between conduit, piping, equipment, architectural, and structural work will be avoided. Building design modifications necessitated by the proposed equipment shall be the responsibility of the Contractor and shall be approved before proceeding with the work.

3.2 INSTALLATION

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NOTE: All pertinent piping and related equipment supports will be designed for seismic forces as specified in subparagraph Support Steel below.

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Equipment and material shall be installed as indicated and in accordance with manufacturer's instructions. A manufacturer's representative experienced in installation of this type of boiler, shall supervise the erection of the boiler and associated equipment.

3.2.1 Piping

Unless otherwise specified, pipe and fittings shall conform to Section 33 63 23 EXTERIOR ABOVEGROUND STEAM DISTRIBUTION.

3.2.2 Field Painting

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NOTE: Where identification of piping is required by the using service, this paragraph will be amplified to include appropriate requirements either directly or by reference to a separate section. Air Force requirements are covered in AFM 88-15.

****

All ferrous metals not specified to be coated at the factory shall be cleaned, prepared, and painted as specified in Section 09 90 00 PAINTS AND COATINGS. All exposed pipe covering shall be painted as specified in Section 09 90 00 PAINTS AND COATINGS. Aluminum sheath over insulation shall not be painted.

3.2.3 Insulation

Shop- and field-applied insulation shall be as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS unless otherwise specified. Breaching, unjacketed boilers, [dust collectors,] and induced draft fan housings shall be insulated with magnesia, mineral wool, calcium silicate, or approved mineral insulation. Insulation may be either block or blanket. Joints in the insulation shall be filled with magnesia, mineral wool, or a suitable cement.

3.2.4 Foundation

Boiler foundation shall be constructed of [21] [_____] MPa [3000] [_____] psi concrete as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE. Anchor bolts shall be set accurately and shall be of adequate length to install the boiler. When embedded in concrete, anchor bolts shall be provided with plates welded on the head and shall be protected against damage until the equipment is installed. Plates shall conform to ASTM A36/A36M.

3.2.5 Equipment Structural Support

3.2.5.1 Structural Steel

Design structural steel equipment supports in accordance with Section 05 12 00 STRUCTURAL STEEL.

3.2.5.2 Support Steel

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NOTE: Provide seismic requirements, if a Government designer (Corps office or A/E) is the Engineer of Record, and show on the drawings. Delete the bracketed phrase if seismic details are not included. UFC 3-301-01 and Sections 13 48 73 and 23 05 48.19, properly edited, must be included in the contract documents.
****

Design support steel to resist all applicable dead and live loads. Design for seismic loads shall be as specified in UFC 3-301-01 and Sections 13 48 73 SEISMIC CONTROL FOR MECHANICAL EQUIPMENT and 23 05 48.19 [SEISMIC] BRACING FOR HVAC [as indicated]. Show a complete loading and support diagram on the detail drawings. Equipment supports shown on the contract drawings are for a general equipment layout and may not conform to the system furnished. Piers and footings may be relocated to suit equipment furnished if no interference with other footings is encountered. Support steel shall comply with ASTM A242/A242M and be fabricated in accordance with the provisions of Section 05 05 23.16 STRUCTURAL WELDING or field bolted using ASTM A325M ASTM A325 high strength bolts. Submit manufacturer's design data and structural computations for walls, roof, foundations, and other features for specialty type of construction, with design data for lateral forces that

may be encountered due to wind loads and seismic forces. Include in the design data manufacturer's equipment design data.

3.2.5.3 Column Base Plates

Design column base plates to bear on a [21] [_____] MPa [3000] [_____] psi concrete floor slab.

3.2.5.4 Anchor Bolts

Anchor bolts shall be ASTM A307 anchor bolts. Anchor bolt sizes and locations shall be shown on the detail drawings.

3.2.6 Stack Support

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NOTE: Indicate wind force the stack design will have to withstand. Structural design will also include seismic resistance as specified in subparagraph Support Steel above.

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Stack support shall be in accordance with NFPA 211, as applicable. Vertical and lateral supports for exterior chimneys shall withstand wind forces of [130] [_____] km/hour [80] [_____] mph.

3.2.7 Catwalks and Access Platforms

All necessary platforms, ladders, handrails, and stairs needed for safe and efficient operation and maintenance of the equipment shall be furnished and installed. They may be relocated from the wall openings and passageways shown in order to suit the boiler equipment provided. All railings shall have 100 mm 4 inch wide toe-board located not more than 6 mm 1/4 inch above the floor level. Construction shall conform as close as practical to items indicated. Fabrication, materials, and coatings shall conform to Section 05 12 00 STRUCTURAL STEEL.

3.2.8 Control System Installation

Install equipment in accordance with the manufacturer's instructions and approval by the Contracting Officer. All control conduit, wiring and/or tubing not specified elsewhere, but required to provide a complete and operable system shall be furnished and installed under this section of the specifications. This shall include material and items required to arrange the system to compensate for the actual field conditions encountered. Copper, stainless steel, or nonmetallic tubing may be used as appropriate. Copper shall be ASTM B88M ASTM B88, Type K; with flared cast brass or wrought copper fittings. Pneumatic tubing shall be 6.4 mm 1/4 inch OD with a minimum wall thickness of 0.762 mm 0.030 inch unless otherwise indicated. Where 9.5 mm 3/8 inch or 12.7 mm 1/2 inch OD tubing is used, the wall thickness shall be a minimum of 1.245 mm 0.049 inch. The extent, general location, and arrangement of the system shall be as indicated. Control panels shall be located as indicated and placed so that operating personnel may effectively monitor boiler operations, but shall not be in a position that would interfere with those operations. Equipment, instruments, piping, wiring, and tubing shall fit into the space allotted and allow adequate clearances for entry, servicing, and maintenance. Locally mounted instruments shall be installed in such a manner as to prevent interference with mechanical installations and to

ensure readability from the front aisles or operating area of the equipment. Installation of the instrumentation system shall be carefully coordinated with the work of other trades.

3.2.9 Field Tubing

Tube fittings shall be compression type and compatible with tubing material (e.g., brass for copper tubing, stainless steel for stainless steel tubing, and nonmetallic for nonmetallic tubing). Each connection shall be checked for proper tightness and installation. All piping between primary connections and instruments shall be a minimum of 9.5 mm 3/8 inch OD tubing. All copper instrument single connecting lines shall be provided with brass, ASTM B61, 20.7 MPa 3000 psi rating, forged body screws or tube ends.

3.2.9.1 Tubing Supports

PVC-coated expansion metal troughs or epoxy-coated vertical unistrut racks shall be used as tubing supports. No elbows, tees, or crosses shall be used. Where the trough branches or changes direction, a suitable gap for the transition will be acceptable. The tubing shall be unsupported over the gap.

3.2.9.2 Air Supply

Instrument air supply headers shall be as shown. Instrument air shall be distributed through the area at nominally 620 kPa 90 psig. Pressure shall be reduced to that required at the instrument by a local regulator. An air set unit shall be furnished and installed for each instrument that has a pneumatic output signal (e.g., transmitter, transducer, controllers, positioner, and relay). Air set units shall have a filter regulator with integral drip-well and drain cock and output gauge.

3.2.10 Electrical

Instrumentation and power-interconnecting wiring shall be as [shown] [recommended by the manufacturer] and as specified in NFPA 70. All external wiring to the control panels shall terminate on terminal boards or on devices in the panels. All cable wire and cable runs shall be carried in conduit or wireways. All signal wiring used for alarm or measurement of control circuits shall be run in conduit separate from power circuits. Direct current signals used for electronic transmission may be run in multiconductor cables. Wiring for control, shutdown, or interlock circuits may be run in the same conduit with power wiring as shown. Instruments shall not be fed from lighting branch circuits. Termination of all wires on instrument binding screws shall be made with solderless insulated shoulder ring-tongue lugs of the proper size for the wire and binding screw. Lugs shall be properly and securely crimped to the wire using the tool recommended by the lug manufacturer. Any termination that is made improperly shall be cut off and a new lug installed. Stripping of all wire shall be done with an approved stripping tool or in such a manner as not to damage the conductor.

3.2.10.1 Cable Conductor Identification

Identification shall be permanently attached to each wire terminating on a terminal board or binding screw to facilitate maintenance. Identification shall be by means of plastic sleeving with printed markings, permanently attached stamped foil markers, or other approved means. Wire numbers

shall correspond to wire numbers shown.

3.2.10.2 Relays

Industrial relays shall be provided for interlocking circuits. Contacts and coils shall be accessible for cleaning and replacement.

3.2.11 Steam Flowmeter Installation

Transmitters shall be mounted at the orifice flanges. Impulse lines shall be sloped to eliminate liquid or gas pockets. Meter manifolds shall be three-valved, except a five-valve manifold shall be used when the meter is sealed or purged.

3.3 MANUFACTURER'S SERVICES

Provide the services of a manufacturer's representative who is experienced in the installation, adjustment, and operation of the equipment specified. The representative shall supervise the installing, adjusting, and testing of the equipment. Ensure that sufficient lead time is given to prevent installation delay resulting from late delivery of equipment and materials.

3.4 TESTING

3.4.1 General

Before requesting the performance and acceptance test, final checking of systems installations and preliminary operation testing and adjustments of all systems shall be conducted in accordance with the manufacturer's recommendations and the requirements of the specifications. All tests shall be scheduled in advance and conducted at times approved. Perform testing in the presence of the Contracting Officer. Submit test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Each test report shall indicate the final position of controls. Submit a written statement from the manufacturer's representative certifying that control equipment has been properly installed and is in proper operating condition, upon completion of the installation. Provide the action settings for all automatic controls in the form of a typed, tabulated list indicating the type of control, location, setting, and function. The test report booklet shall include logs, thermal efficiency calculations, tabulated results, and conclusions.

3.4.1.1 Schedule for Testing

Notify the Contracting Officer in writing at least [20] [_____] days in advance of the intent to test the boilers, and submit a testing schedule. The Contracting Officer will notify the appropriate authorities.

3.4.1.2 Visual Inspection

Examine each boiler for defects outlined below:

a. Parts of components missing.

b. Improper assembly.

c. Parts or components not functioning properly.

d. Workmanship not as specified.

e. Exposed edges of metal not smooth.

f. Materials not as specified.

3.4.1.3 Repairs

Replace all defective parts furnished and installed by the Contractor and complete all repairs identified during capacity and operating tests.

3.4.2 Instrumentation Tests

Test all instrument systems after completing the following activities:

a. Inspect complete work and make any nonoperating checks required to assure operability in the manner required for the process application.

b. Check instrument air lines and wiring for proper hookup.

c. Test air lines for tightness according to the requirement of the Instrument Society of America Recommended Practice ISA 7.0.01.

d. Commission instruments, controls, interlocks, alarms, and related items. Include operating checks, provision and installation of seals as required, checking and adjusting settings, standardizing and calibration, and proof tests.

e. Install relief valves and filter regulator sets.

f. Insulate and winterize instruments.

If all of the above cannot be completed before startup, advise the Contracting Officer in writing 2 weeks before testing.

3.4.3 Dielectric Tests

Test electrical system for dielectric strength. Electrical system, excluding control and recording instruments, shall be subject to a voltage of twice its rated voltage, plus [500] [_____] volts, for a period of not less than [1] [_____] minute. Before testing, all instruments and operating mechanisms that could be damaged shall be disconnected. After the test, the circuit shall still register a resistance of not less than 1 megohm at [600] [_____] volts dc. This test shall apply between all insulated circuits and external metal parts.

3.4.4 Control Tests

Ttest boiler under actual firing conditions. Verify with the tests that all controls function within the maximum and minimum limits for temperature or timing. Unsafe conditions, such as high temperatures, shall be simulated during the tests by reducing the settings for activation of limit and safety controls.

3.4.5 Necessary Temporary Piping

Necessary temporary test piping not less than [100] [_____] mm [4] [_____]

inches in diameter shall be furnished. A steam silencer to exhaust excess steam to the atmosphere in the event the boiler load is insufficient to meet the capacity specified shall be provided. A control valve for exhausting excess steam to atmosphere shall be provided in a convenient location inside the boiler room.

3.4.6 Test of Deaerating Feedwater Heater

Test of the deaerating feedwater heater shall comply with ASME PTC 12.3 and demonstrate that the equipment installed shall meet the requirements specified as to performance, capacity, and quality of effluent. During the operating test of the boilers, tests shall be conducted to determine oxygen content in accordance with ASTM D888, Method A. Boilers shall be operated at varying loads up to maximum heater capacity while oxygen tests are being made.

3.4.7 Test of 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. Boiler water conditioning shall include chemical treatment and blowdown periods to prevent scale and corrosion in boilers and in supply and return distribution systems from the initial start of the system, through the testing period, and to final acceptance of the completed work. Approved chemicals and method of treatment shall be used.

3.4.8 Hydrostatic Tests

Following erection, each boiler shall be tested hydrostatically and proved tight under a gauge pressure of 1-1/2 times the working pressure specified. Following the installation of all piping and boiler house equipment, but before the application of any insulation, hydrostatic tests shall be made and the system shall be proved tight under gauge pressures of 1-1/2 times the specified working pressure. Boilers shall be tested and the piping connections inspected by an NBBI-commissioned boiler inspector for determining compliance with all requirements in ASME BPVC SEC VIII D1, and the Contracting Officer shall be supplied with a certificate of approval for each boiler. Shop foam shall be applied to all seams to detect leaks. Boiler shall not lose more than [1.27] [_____] kPa [5] [_____] inches water gauge in [10] [_____] minutes.

3.4.9 Test for Steam Purity and Water Level Stability

Test for steam purity, in accordance with ASTM D1066, and water level stability shall be simultaneous under the operating conditions specified.

3.4.9.1 Steam Tests

Steam tests for boiler over [2.07] [_____] MPa [300] [_____] psig, without superheaters, not used for power generation or large turbine drive, shall be made on steam sampled in accordance with ASTM D1066, using the conductivity method in ASTM D2186. The conductivity of the steam corrected for carbon dioxide and ammonia content shall not exceed 30 microhms at 18 degrees C. Steam for boilers less than [2.07] [_____] MPa [300] [_____] psig, with or without superheat, used for power generation or turbine drive for air-conditioning equipment shall be sampled in accordance with ASTM D1066 and shall be tested in accordance with the conductivity method in ASTM D2186. The conductivity of the steam

corrected for carbon dioxide and ammonia content shall not exceed 4.0 microhms at 18 degrees C 60 degrees F. Steam shall be tested for moisture in accordance with calorimetric method outlined in Part II of ASME PTC 19.11.

3.4.9.2 Water Level Stability Test

Water level stability test first shall be conducted by use of the manual bypass around the feedwater regulator. Test then shall be repeated using the automatic feedwater regulator. Boiler shall maintain specified water level stability under both conditions.

3.4.10 Performance Tests

Submit a proposed performance test procedure for the operating [and environmental] tests, 30 days prior to the proposed test date. The procedure shall contain a complete description of the proposed test with calibration curves or test results furnished by an independent testing laboratory of each instrument, meter, gauge, and thermometer to be used in the tests. The test shall not commence until the procedure has been approved. The Contractor's complete plan for water treatment, including proposed chemicals to be used and nationally recognized testing codes applicable to the system, shall be included and approved prior to system startup.

a. Upon completion of installation, the boiler and associated equipment and instrumentation shall be subjected to such operating tests as may be required to demonstrate satisfactory functional operation.[Stack sampling for compliance with applicable emission limits is covered under Section 23 52 00 HEATING BOILERS.] Testing shall be in accordance with the test procedures indicated below and shall be in accordance with the requirements of ASME PTC 19.10. All pressure measurements are to be taken in accordance with ASME PTC 19.2, and all temperature measurements are to be taken in accordance with ASME PTC 19.3 TW. Furnish all instruments, equipment, and personnel required for the tests. The Government will supply water, electric power, and fuel. Two instruction manuals shall be available at all times during the tests.

b. An efficiency and capacity test shall be run on one boiler of each size installed, conducted in strict accordance with ASME PTC 4, abbreviated efficiency test, utilizing the input-output method, except for use of alternate measuring or metering devices properly calibrated before the test, for the purpose of metering the water used and change in the temperature of flue gas. Combustion gases entering the heat recovery boiler shall be analyzed and recorded. Record CO, CO2, H2O, O2, N2, HCl, SO2 and temperature. Water meter used in the test shall be suitable for hot water. Efficiency shall be not less than specified. Maximum moisture content of saturated steam leaving the boiler shall be as specified. Efficiency and general performance tests on the boilers shall be conducted by a qualified test engineer. Calibration curves or test results furnished by an independent testing laboratory of each instrument, meter, gauge, and thermometer to be used in efficiency and capacity tests shall be furnished before the test. All indicating instruments shall be read at 1/2-hour intervals unless otherwise directed. Instruments required for conducting the boiler tests are contained in ASME PTC 4 and ASME PTC 19.11.

3.5 CLEANING OF BOILERS AND PIPING

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NOTE: Local guidelines may dictate the maximum discharge rate for cleaning chemicals into the sanitary sewer system.

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After the hydrostatic tests, but before the operating tests, clean the boilers of foreign materials. Wherever possible, surfaces in contact with water shall be wire brushed to remove loose material.

a. The following procedure may be used or submit other standard procedure for review and approval by the Contracting Officer. Fill boilers with a solution consisting of the following proportional ingredients for every 1000 liters gallons of water and operated at approximately 200 to 350 kPa 30 to 50 psig for a period of 24 to 48 hours, exhausting steam to the atmosphere:

   (1) 2875 g 24 pounds caustic soda.

   (2) 2875 g 24 pounds disodium phosphate (anhydrous).

   (3) 960 g 8 pounds sodium nitrate.

   (4) 60 g 1/2 pound approved wetting agent.

b. Chemicals in the above proportions or as otherwise approved shall be thoroughly dissolved in the water before being placed in the boilers. After the specified boiling period, the boilers shall be allowed to cool, then drained and thoroughly flushed. Piping shall be cleaned by operating the boiler for approximately 48 hours, wasting the condensate.

c. Provide boiler water conditioning, including chemical treatment and blowdown during periods of boiler operation to prevent scale and corrosion in boilers and in supply and return distribution systems from the initial startup of the system, through the testing period and to final acceptance of the completed work. Approved chemicals and method of treatment shall be used.

3.6 FRAMED INSTRUCTIONS

Provide framed instructions under glass or in laminated plastic, including wiring and control diagrams showing the complete layout of the entire system, equipment, piping, valves, and control sequence. Post the instructions where directed. Condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system shall be prepared in typed form, framed and posted beside the wiring and control diagrams. Submit posted diagrams, instructions, and other sheets, before posting. Post framed instructions before acceptance testing of the systems.

3.7 FIELD TRAINING

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NOTE: Consult equipment manufacturers for recommended time required to train personnel for the

proper operation of the unit and insert number of hours.
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Provide a training course for designated operating, maintenance, and supervising staff members. Provide training for a total period of [_____] hours of normal working time, starting after the system is functionally complete, but prior to final acceptance tests. Field training shall cover all of the items contained in the approved operating and maintenance instructions as well as demonstrations of routine maintenance operations. Submit [6] [_____] complete copies of operating instructions outlining the step-by-step procedures required for system startup, operation, and emergency shutdown. The instructions shall include the manufacturer's name, model number, service manual, parts list, and brief description of all equipment and their basic operating features. Submit [6] [_____] complete copies of maintenance instruction listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides. The instructions shall include piping layout, equipment layout, and simplified wiring and control diagrams for the system as installed, and other information necessary for equipment maintenance. Field training shall also include recommendations for total staffing and job descriptions. Notify the Contracting Officer at least 14 days prior to date of proposed conduction of the training course.

3.8 OPERATING TEST

Perform test at full-scale for 24 hours, or longer if required by the combustion equipment specifications. During this period, the boilers shall supply the rated amount of steam at the temperature, pressure, and thermal efficiency specified when the unit is supplied with the rated amount of hot gases at the specified temperature. The entire unit shall maintain this efficiency during the entire test period. After [4] [_____] hours, temperature readings of the outer shell, taken at not less than five random locations, shall not exceed the temperature limitation specified. Boilers shall also demonstrate the ability to operate well with the combustion equipment and to follow changing load demands while maintaining specified steam temperature and pressure based upon the limitations of the equipment. At the conclusion of testing, the boilers shall be inspected for deterioration such as slagged or spalling refractory, warping of parts, and discolored exterior paint.

-- End of Section --