Preparing Activity: USACE Superseding without Revision
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UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023
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DIVISION 23 - HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)

SECTION 23 52 30.00 10

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05/20

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HEAT RECOVERY BOILERS
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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

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	(2022) Nuts for General Applications: Machine Screw Nuts, and Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)
ASME B31.1	(2022) Power Piping
ASME B40.100	(2022) 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	(2021) Control and Safety Devices for Automatically Fired Boilers
ASME MFC-3M	(2022) 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	(2021) 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 2021) 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	(2023) 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; R 2023) 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	(2021a) Standard Specification for Steel Castings, Iron-Chromium and Iron-Chromium-Nickel, Heat Resistant, for General Application
ASTM A307	(2021) 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	(2023) Standard Specification for Carbon and Low-Alloy Steel Forgings, Requiring Notch Toughness Testing for Piping Components
ASTM A515/A515M	(2017; R2022) 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	(2018; R 2022) Standard Specification for Welded Austenitic Stainless Steel Feedwater Heater Tubes
ASTM B61	(2015; R 2021) Standard Specification for Steam or Valve Bronze Castings
ASTM B68/B68M	(2011) Standard Specification for Seamless Copper Tube, Bright Annealed (Metric)
ASTM B88	(2022) 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	(2023) Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel
ASTM B766	(2023) Standard Specification for Electrodeposited Coatings of Cadmium
ASTM C27	(1998; R 2022) Fireclay and High-Alumina Refractory Brick
ASTM C155	(1997; R 2022) Standard Specification for Insulating Firebrick
ASTM C401	(2012; R 2022) 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; R 2022) 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	(2021) Motors and Generators
NEMA SM 23	(1991; R 2002) Steam Turbines for Mechanical Drive Service

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023) National Electrical Code
NFPA 85	(2023) 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	(2020) HVAC Duct Construction Standards Metal and Flexible, 4th Edition

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE J534	(2021) Lubrication Fittings

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-301-01	(2023) 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 must be capable of fully independent or simultaneous operation. The normal mode of operation must be the same as for the heat source. Vary combination of unit systems to optimize running times; therefore each unit system must 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. Use qualified procedures and welders 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 must apply his assigned symbol near each weld he makes as a permanent record. The welders mark must not deform or remove metal. Weld structural members 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, submit proof of such conformance. 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, provide design, fabrication, testing, and installation conforming 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. Support list of materials and equipment by descriptive material, such as catalog cuts, detailing conformance with the specification requirements. Catalog numbers alone will not be acceptable. 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, include details of such departures, including changes in related portions of the project and the

reasons therefore, 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, couple the heat recovery boiler with the same type of combustion equipment as stated in the bid package. Provide equipment supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the plant site. Provide controls of a type that has given satisfactory field performance under normal operating conditions for no 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. Guard or cover high-temperature equipment and piping over 66 degrees C 150 degrees F exposed to contact by personnel or where it creates a fire hazard properly 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, factory prime paint surfaces of ferrous metal subject to corrosion with a rust inhibiting coating and subsequently factory finish painted in accordance with the manufacturer's standard practice. Prime and finish paint equipment exposed to high temperature when in service with the manufacturer's standard heat resistant paint to a minimum thickness of 0.025 mm 1 mil. Use a light color finish paint.

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.
****

Provide each boiler system with the capacity described herein and as shown on the contract drawings. The equipment design and accessory installations must permit accessibility for maintenance and service. Design boilers for a maximum allowable working pressure of [_____] kPa psig with an operating pressure of [_____] kPa psig. Design conditions are 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

Provide boiler that is capable of operating continuously at maximum specified capacity without damage or deterioration to the boiler, setting, heat source equipment, or auxiliaries. The boiler must be capable of automatically controlled operation while coupled to the heat source. Design the equipment 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 must be evidenced by applicable "P" forms before acceptance of the facility by the Government. Provide boiler piping under ASME B31.1. Equip each boiler with an [economizer] [air preheater]. Boiler unit or heat recovery section must be a standard part of a steam generation system package closely coupled to the combustion equipment.

2.2.1 Capacity

Rated capacity is the capacity at which the boilers will operate continuously without exceeding the specified boiler heat transfer rates, and boiler exit temperature. Provide boiler auxiliaries including fans, motors, drives, and similar equipment 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.

****

Provide electric motor-driven equipment specified complete with motors and necessary motor control devices. Provide motors, motor control devices, and power supply wiring conforming to Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM including requirements for hazardous area locations. Use premium efficiency type integral size motors in accordance with NEMA MG 1. Submit a complete electrical connection diagram for each piece of mechanical equipment having more than one automatic or manual electrical control device for approval before installation. Provide motors with enclosures as indicated.

2.2.2.1 Motor Ratings

Use motors that are suitable for the voltage and frequency provided. Motors 373 W 1/2 horsepower and larger must be three phase, unless otherwise indicated. Ensure ratings are adequate for the duty imposed, but are not less than indicated. Provide motors conforming to NEMA MG 1 with enclosure as specified. Motors smaller than 746 W Fractional horsepower motors must be Type I, Class 1B or Class 2A or 2B, Continuous Duty. Motors larger than 746 W Integral horsepower motors must 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, provide a motor starter. Where required, provide motor starters 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. Provide 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. 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.
****

Ensure each boiler is suitable for indoor installation and include a heat recovery [fire] [water]-tube section and a steam separator. Design tube section so the tubes are installed in an arrangement that will permit ease of access and replacement. Fire boilers with the hot gases generated by the associated combustion equipment. Draw hot gases [through] [over] the tube banks by an induced draft fan. Control gas flow 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. Provide boilers that are [either] [fire-tube] [or] [single or multiple drum, bare-tube, water-tube, natural circulation]. Provide sootblowing systems with coordinated controls.

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

****

Limit the maximum effective radiant heating surface 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) must 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, do not exceed 1093 degrees C 2000 degrees F.

2.2.3.3 Radiant Heating Surface

Effective radiant heating surface for water-tube boilers must 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 must 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 must be the total water-backed area within the furnace boundaries exposed to the flame. Use the mean circumference for corrugated crown sheets.

2.2.3.4 Boiler Operating Capacity

The boiler must 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. Ensure the hot gas entrance temperature is [_____] degrees C degrees F and the flue gas outlet temperature is [_____] degrees C degrees F, based on a flow of [_____] actual cubic meters/second ACFM. Ensure moisture in the steam and boiler water concentrations is 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, 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, provide energy consuming products and systems that meet or exceed the requirements of ASHRAE 90.1.

****

Base output capacity of the boilers on tests of the boilers and combustion equipment as a unit. Provide a minimum efficiency of [80][_____] percent at maximum continuous capacity.

2.2.3.6 Boiler Markings

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

Furnish each boiler with a metal nameplate including 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 must 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

Provide materials exposed to the internal environment of the boiler that are compatible with the temperature and atmospheric conditions which they will encounter. Do not use dissimilar metals that, when in contact or otherwise electrically connected to each other in a conductive solution, generate an electric current, in intimate contact.

2.3.2 Lubrication

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

2.3.2.1 Lubrication Fittings

Locate lubrication fittings in accessible protected positions. Paint a bright red circle around each point. Provide carbon steel balls, bodies and tips of fittings. Threads of fittings must be 1/4 - 28 taper, straight or 1/8 pipe threads. Incorporate a surface ball-check valve located at the surface of the inlet tip into fittings. Use cadmium plated carbon steel fittings 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 is 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, affix a suitable warning or caution plate to the equipment in a conspicuous location.

2.3.3 Lifting Attachments

Equip each unit 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

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

2.3.5 Interchangeability

Manufacture all parts to standards that will permit replacement without modification to parts or equipment.

2.3.6 Surfaces

Finish or paint all surfaces as specified in paragraph PAINTING AND FINISHING.

2.3.7 Fastening Devices

Provide bolts and nuts that are suitable and conforming to ASME B18.2.1 and ASME B18.2.2 respectively. Ensure all screw threads conform to the requirements of ASME B1.1. Install all screws, pins, bolts, hydraulic fittings, and similar parts with a means to prevent loss of tightness. Ensure such parts subject to removal or adjustment are not swagged, peened, staked, or otherwise permanently deformed.

2.3.8 Electrical

Bring all wiring to a single location. Provide factory wired equipment 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. Make wiring neat and secure.

2.3.9 Castings and Forgings

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

2.3.10 Welding, Brazing, Soldering, Riveting, or Wiring

Employ welding, brazing, soldering, riveting, or wiring only where these operations are required in the original design.

2.3.11 Refractory and Insulation

Use manufacturer's proven standard design for refractory and insulation systems. 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. Install plastic refractory in accordance with the manufacturer's recommendations and by workmen skilled in its application. Provide insulation systems consisting of the manufacturer's proven standard materials and methods and submit with data as to adequacy of material. Field repair hot spots exceeding requirements as directed. Field install exposed areas as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.3.11.1 Insulation

Where specified or indicated, insulation must 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. Provide Class 5 mineral fiber block insulation conforming to ASTM C612. Lay insulating block in approved mortar specifically manufactured for this purpose or recommended by the insulating material manufacturer. Provide firebrick conforming to ASTM C27 and ASTM C155. Interpret firebrick to include straight brick, radial brick, wedge brick, skew-type brick, cupola blocks, and other similar shapes. Lay firebrick up in air-setting mortar. Dip each brick in mortar, rub, push into place, and then tap with a wooden mallet until it touches the adjacent bricks. Mortar thick enough to lay with a trowel will not be permitted. Use mortar conforming to ASTM F1097. Do not exceed maximum mortar joint thickness of 3.2 mm 1/8 inch and average joint thickness of 2.0 mm 1/16 inch. Insulate main arches of the boiler and flue connection above the firebrick and, where exposed to the weather, protect with a suitable concrete or brick slab. Insulate firebrick floors 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 is [_____] 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

Provide joints in the firebrick masonry at [approximately the locations shown] [spacings of approximately 2.44 meters 8 feet]. Provide joints that are 12.7 mm 1/2 inch wide and 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 changed as necessary, by offset or otherwise, to avoid weakening the arch over an opening.] Expansion joints 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 are not permitted. When joints are offset, do not bond the horizontal faces between the two courses of brick along the offset. In addition, to allow for expansion of the inner face, provide a series of 3.2 mm 1/8 inch wide vertical openings spaced 1.8 m 6 feet apart on the furnace side of the wall. Make proper provision for expansion and contraction between boiler foundation and floor.

2.3.12 Boiler Setting

Construct boiler to comply with ASME BPVC SEC VIII D1 and provide 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

Provide foundation structure and install in accordance with manufacturer's recommendations and as indicated. Use structural systems supporting pressure parts, tubes, and refractory with a safety factor to permit delivery of boiler, jacking, and rigging.

2.3.12.2 Supports

Provide boilers and separator drums 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

Construct casing or shell sides of carbon steel materials no lighter than 3.416 mm 0.1345 inch thick, either bolted or welded. Provide gas-tight casing and reinforce with steel ribs or stiffeners to provide rigidity and prevent buckling. Insulate boiler casing fully with sufficient thickness to limit the casing temperature as specified. Equip boiler shell with all necessary connections including outlet nozzles, return connections, and connections for pressure relief valves, water level controls, and other required trim. Provide manholes, handholes, and observation ports in accordance with ASME BPVC SEC I. Equip boilers with gas-tight observation ports.

2.3.12.4 Expansion and Contraction

Make adequate provisions for expansion and contraction of the boiler unit and associated breaching to prevent damage to the support structure or the equipment and associated ductwork. Make provisions for expansion and contraction between boiler foundation and floor. Pack joints with oakum and fill with a suitable compound that will not become soft at temperatures of 49 degrees C 120 degrees F.

2.3.13 Water-Tube Boiler

Provide a shop fabricated and field erected boiler or a packaged unit. 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. Include setting refractory, insulation to maintain a casing temperature of no 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 (do not use asbestos material), and welded or doubled wall casing. Provide hinged access opening covers.

2.3.13.1 Drums or Dome Space

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

2.3.13.2 Drum Outlets

Apply drum outlets in approved manner and of approved strength in accordance with ASME BPVC SEC I. Outlets include but are not 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

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

2.3.13.4 Baffles

Arrange baffles to bring the products of combustion into contact with the heating surfaces without excessive loss of draft. Ensure baffles are gas-tight and are either a refractory material or metal suitable for temperatures encountered.

2.3.14 Fire-Tube Boiler

Provide packaged type boiler and include programming control system with capacity as indicated. Provide hinged access opening covers.

2.3.15 Boiler Internals

2.3.15.1 Internal Fittings

Use securely mounted and demountable internal fittings for boiler access and cleaning. Internal fittings include, but are not 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

Provide flanged outlet fittings 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.] Provide all devices, designs, and piping methods in full accordance with applicable provisions of ASME BPVC SEC I for pressure piping and evidence by proper certificates of work performance and inspection.

2.3.15.3 Openings

Flash or seal steam outlets, safety valves, and other valve openings in outer casing at top of boiler 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.
****

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

2.3.16 Access Doors

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

2.3.17 Miscellaneous Pipe Connections

Provide miscellaneous pipe connections 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. Provide soot blowers if the combustion source utilizes solid fuel. Provide a suitable smoke outlet with steel frame, damper, and damper shaft. Provide damper with external high temperature roller or ball bearings at both ends of the shaft, and with 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.
****

Provide [one] [two] observation port[s] 80 mm 3 inches in diameter on each access door and consisting of 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. Extend tube or duct from the exterior of the casing to no less than one-half the thickness of the refractory opening and make gas-tight. Make provision 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.
****

Provide test holes as indicated and fit with standard weight, 50 mm 2 inch diameter, black steel pipe. Extend sleeve from the exterior of the casing to no less than one-half the thickness of the refractory lining. Form refractory opening from the end of the pipe sleeve to the interior wall surface to shield the end of the sleeve from reflected heat. Fit sleeve with a brass screw cap and security chain. Weld two or more sturdy lugs in approximately the middle of the length of each test pipe to prevent the pipe from turning when the cap is being removed.

2.3.20 Safety Devices

Use boilers 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

Equip low points of all piping and tubing with drains for freeze protection.

2.3.22 Fire Protection

Provide boilers meeting the requirements of NFPA 85.

2.4 BOILER AUXILIARY EQUIPMENT

2.4.1 Boiler Fittings and Appurtenances

Provide boiler fittings, and all other boiler appurtenances complying with ASME BPVC SEC I. Provide boilers 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. Make blowoff provisions from the mud drum or lower part of a fire-tube boiler. Provide pressure gauges for high-pressure steam units which include a siphon, gauge cock, and test connection. Ensure trim and appurtenances include a 150 mm 6 inch minimum pressure gauge and a safety valve. Provide a chemical feed connection with internal distribution pipe.

2.4.1.1 Water Column

Provide water column with straight-through type drain valve. Provide

water column 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. Also include a test valve, blowdown valve, and a straight-through type drain valve. Do not combine water column with the low water cutoff. [Provide water column lighting 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.

****

Provide a low-water cutoff, with alarm located on instrument panel, and include either a float-actuated switch as a means of making electrical contact or an electrically-actuated probe type low water cutoff. Provide float chamber with a blowdown connection. The cutoff must cause a safety shutdown and sound an alarm when the boiler water level drops below a safe minimum level [and route hot gases from the combustion equipment to the bypass stack]. [Install two low-water cutoffs on each boiler. Pipe low-water cutoffs for the boilers separately with separate drum connections. Provide a separate housing for each low-water cutoff. Two elements in one housing will not be permitted.] A safety shutdown due to low-water cutoff must require a manual reset before operation can be resumed and must prevent recycling of the combustion equipment. The cutoff must 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

Provide feed and check valves 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.

****

Provide manual proportioning continuous blowdown valves, fabricated of corrosion-resistant steel. Provide valves with a micrometer dial setting and a chart listing the capacities through the complete range of micrometer settings at the boiler pressure. Provide valves conforming to ASME BPVC SEC I. Provide blowoff valves in tandem at each point of blowdown as recommended by the boiler manufacturer. Provide piping consisting of extra-heavy weight, minimum, steel pipe conforming to ASTM A106/A106M Grade B. Use balanced, seatless type slow opening valves unless otherwise approved. Provide both surface and bottom blowdown connection points with required accessories. Provide valves with a capacity equal to the capacity of the boiler and forged steel bodies with socket weld connections. Provide valve with a solid Stellite disk with

stainless steel seat sleeves. Design the bodies for a minimum working pressure of 2.07 MPa 300 psig. Quick opening valves must be lever operated, flat seat sliding disks with sealing bushing on the inlet side, and double tightening on both sides of the disk. Provide gear operated quick opening valves. All blowoff valves must be suitable for safe blowdown through the piping system installed. Supply all pipe, valves, and fittings as necessary to allow tie-in to a central point for surface and bottom blowdown.

2.4.1.5 Safety Valves

Provide safety valves of proper size and of the required number and construction and set pressures in accordance with ASME BPVC SEC I and install so that the exhaust steam will discharge through pipes extending through the roof. Provide a drip-pan elbow for each exhaust riser to prevent the accumulation of water on the valve. Provide a suitable slip joint between the drip-pan elbow and the riser. Each exhaust head must 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 must be larger than through the connecting pipe. Set valves to discharge at 10 percent above the operating pressure of the system.

2.4.1.6 Steam Nonreturn Valves

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

2.4.1.7 Feedwater Regulator

Connect feedwater regulator, sized for the application, complete with all necessary piping and accessories for automatic operation. Provide valved bypass around the control valve. Provide units with a device to lock the regulator in existing position in case of power failure. Provide unit with a manual/automatic selector panel located on the instrument panel in the control room. Provide feedwater control element with a drain valve. Fit feed-water line with a thermometer well. Mechanical linkages and chains to position the valve are not allowed. Provide feed-water piping conforming to the requirements of ASME BPVC SEC I. Provide a hand wheel or a manual jacking device 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.

****

Provide soot blowers in conjunction with the heat recovery or boiler

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

2.4.1.9 Drains

Install drains consisting of a 20 mm 3/4 inch hose bib or a 25 mm 1 inch hose gate valve 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

****

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.

****

Use economizers of a type normally provided by the boiler manufacturer and include [finned tubes,] [bare tubes,] baffles and headers and have provision for cleaning and tube bundle removal. At maximum load, economizer exit water must not be within 17 degrees C 30 degrees F lower than saturation temperature. Provide materials capable of withstanding the maximum boiler exit gas temperature plus 28 degrees C 50 degrees F. Provide tubes conforming to ASME BPVC SEC I. Overall design and installation must preclude cold-end corrosion under any load condition. Economizer exit flue gas temperature must be no less than 177 degrees C 350 degrees F and the tube metal temperature must be above the maximum flue gas dew point for the fuel being fired under all load conditions.

2.4.3 Air Preheaters

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

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Use air preheaters of a type normally provided by the boiler manufacturer which are recuperative, tube plate, or regenerative type constructed of materials adequate to withstand the corrosion effects of the flue gases. Overall design must preclude cold-end corrosion of the air preheater under any load condition. Temperatures of all metals in contact with flue gas must be above the flue gas maximum dew point temperature for the fuel

being fired under all load conditions. Control by steam preheat or by automatic bypass and integrate with the combustion control system.

2.4.4 Draft Fans

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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. Provide unit consisting of an electrical motor driven centrifugal fan, a housing (scroll and side plates), controls, guards and accessories. Attach all components to a common base which includes provisions for fastening to a foundation. Provide completely assembled unit, ready for installation and operation.

a. Provide fan assemblies suitable for continuous boiler draft operation to handle flue gases having temperatures up to 800 degrees F. Provide fans complying with AMCA 99 standard applicable to centrifugal furnace fans and that are rated for flow rate, pressure, power, speed of rotation and efficiency in accordance with AMCA 210 and ASME PTC 10. 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. Provide centrifugal fans with backward curved blades or radial tip blades. Size each fan 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, 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. Design induced draft fans for handling hot flue gas at the maximum boiler outlet temperature adjusted for boiler surface fouling. Provide [single] [or] [double] width centrifugal type fans. [When the fan is a double-width centrifugal type, it must have a double inlet.] Ensure the direction of fan rotation is [clockwise] [or] [counterclockwise] as determined from the drive side of the fan. Ensure the direction of discharge is [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 must be [45] [90] [135] [180] [225] [270] [315] [or] [360]. Provide fans with a static efficiency of no less than 0 percent in standard air at best efficiency point. Construct fan wheel of [steel] [or] [aluminum]. Turn, grind, and polish the shaft. Balance the fan wheel and shaft assembly statically and dynamically. Balance the complete rotating assembly of the fan dynamically within the limits of

the following formula:

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

mills-peak-to-peak

Noise levels for fans must not exceed 85 dBA at a 914.4 mm 3 foot station. Provide fan housing consisting of carbon steel of a nominal thickness no 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

Provide continuously welded scroll and sideplate joints. Reinforce housing with steel member to provide a rigid structure and to minimize vibration. [Locate a threaded drain connection to accommodate a 25 mm 1 inch standard pipe at the lowest point in the scroll. Include a flush-type access door in the scroll and hold by quick-release clamps and locate as specified. Provide flanged inlet and outlet duct connections].[Equip the inlet of the fan with an inlet box of the same steel thickness as the housing.] Provide seals to minimize leakage where the shaft passes through the housing or inlet box. [Provide scroll sheets and rotor blades with liners.]

a. Insulate induced draft fans as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS. Factory paint fans with the manufacturer's standard finish. If drawings so indicate, design the induced-draft fan housing to support the portion of the boiler stack that is resting on the housing. Provide fans with [inlet vane control] [inlet damper control] [variable speed control]. Provide inlet vanes or dampers that are suitable for use with combustion control equipment. Equip fan 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. Provide air cooled fan bearings. Provide air balanced pillow blocks or auxiliary seals to prevent the aspiration of oil from oil slinger type bearings. Provide oil reservoir with heat slingers for control of air movement over the bearing housing in order to prevent a buildup of ambient temperature. Provide means for lubrication in accordance with the manufacturer's standard practice. Locate parts requiring lubrications to make the lubricating points easily visible and accessible. Provide hydraulic lubrication fittings 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, affix a suitable warning to the equipment in a conspicuous location. Properly lubricate all parts requiring lubrication before delivery.

c. Drive fans by electric motors. Provide electric motor which is [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 must be magnetic [across-the-line] [reduced voltage start] with [general-purpose] [weather resistant] [watertight] [dust-tight] [explosion-proof] enclosure and furnished with four auxiliary interlock contacts. Connect fans directly or indirectly to the driving motor. If the fan is indirectly connected, provide a V-belt designed for 50 percent overload capacity, and mount the motor on the base in a manner that will permit tightening of the belt.

2.4.5 Flue Ducting

Connect each boiler to the stack or flue by means of a smoke connection constructed of black iron or steel sheet no less than 1.214 mm 0.0478 inch, nominal thickness. Ensure clear distance between any portion of the smoke connection surface and any combustible material is not less than that specified in NFPA 211. Fasten joints and seams securely and make airtight. Provide suitable clean-outs to permit cleaning the entire smoke connections without dismantling. Construct duct conforming 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

Construct breaching of no less than 3.416 mm 10 gauge steel sheets conforming to ASTM A36/A36M. Reinforce and brace breaching adequately with structural steel angles no smaller than 50.8 by 50.8 by 6.4 mm 2 by 2 by 1/4 inch and weld all joints and seams in the sheets and angles. Install flexible type expansion joints that require no packing as indicated and required to suit the installation. Provide breaching with angle flanges and gaskets for connection to boilers, fans, equipment, or stacks with breaching to be the full size of the opening. Line breaching with a minimum of 76.2 mm 3 inch thick refractory. Make gas-tight breaching connections, caulk tight all around and seal with cement to form an air-tight joint. Provide clean-out openings consisting of tight-fitting hinged doors with frames, of suitable size, and at approved locations for access to all sections of the breaching. Locate one 400 by 400 mm 16 by 16 inch inspection door in the side of the breaching just preceding the boiler unit. Locate a similar inspection door just following the boiler unit. Breaching may be supplied in bolted or welded sections for ease of handling and erection and constructed in accordance with SMACNA 1966. Provide connectors 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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Install 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 at the entrance of the waste heat recovery boiler to isolate it from the combustion equipment during emergency boiler repairs. Furnish a [chain hoist] [manual lever]

[electrical control] for raising and lowering the damper and must be of a size and design to ensure free movement by the damper. [Secure the hoist cable to the damper frame by shackles and bolts. Provide damper slot with a steel plate cover 6.4 mm 1/4 inch thick and of the proper length and width. Provide cover with a slot to permit passage of the damper cable, and for easy removal of the damper. Provide hoist that is a product of a manufacturer regularly engaged in the manufacture of hoists. Provide spur geared hoist. Design unit for high-speed lifting, have high mechanical efficiency, an automatic load brake, and a built-in load limit.] The operator must be able to move the required load freely and maintain the damper in any desired position within the limits of the flue opening. Do not exceed a maximum pull of 310 Newtons 70 pounds to operate the unit.

2.4.8 Flue Gas Discharge Dampers

Install a controller-actuated, refractory-lined damper at the boiler exit. Install another damper in the dump stack and open if any of the following conditions occur:

a. Excess boiler steam pressure.

b. Induced draft fan failure.

c. Boiler is shut off.

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

2.4.9 Blowoff Tank

[Construct blowoff tank of 4000 psi reinforced concrete as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE, and fit with a bolted steel manhole cover and frame. Install blowoff pipe, vent pipe, and drain pipe to sewer in pipe sleeves built into the concrete. Fill and caulk space between the pipe and sleeves with lead wool or similar material to make a water-tight connection. Divide tank into two sections by a baffle to form a sediment chamber] [Construct blowoff tank of steel].

2.4.10 Boiler Feed Pumps

Size and design boiler feed pumps for the specific application. Furnish pumps having a combined rating of flow and head that results in a horsepower rating less than 186 kW 250 bhp to meet the design requirements of API STD 610. Provide either end-suction or top suction, top-discharge pump and support at the center line. Pump size with higher ratings than the above must be horizontal-split case, multistage centrifugal pumps. All pump ratings must 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 must not exceed 80 percent of the available system NPSH at the same flow, assuming a low level in the storage tank. Ensure guaranteed NPSH requirements reflect 3 percent breakdown criteria. Ensure the pump's head-capacity (H-Q) curve is constantly rising to shutoff with no point of inflection. There must be no restriction to operation at any point from continuous flow to design flow. Provide turbine type pumps, bronze fitted throughout, with impellers of bronze or other corrosion-resistant metal as approved. Fit pump barrel assemblies with lifting rings. Use capacities

and characteristics as indicated.

2.4.10.1 Casings

Construct casing using either volute or diffuser design and support at its centerline. Provide pumps with integrally cast suction and discharge flanges that are drilled to meet the design pressure of the application. Use a maximum operating temperature, for design purposes, of any feedpump that is no less than 204 degrees C 400 degrees F. Drill and tap casings. Provide casings with vent, gauge, and drain connections. Pumps designed for this service must not require cooling at ratings below 370 kW 500 bhp. This applies to both frame cooling or seal cooling. Below 370 kW 500 bhp, employ antifriction radial and thrust bearings lubricated by flinger rings in a sealed housing. Provide seals consisting of mechanical and air-cooled flush piping conforming to API STD 610, Plan 23. Above 370 kW 500 bhp, employ a single cooling circuit for both cooling and delivering the oil by a forced-oil system to sleeve radial bearings, and a floating shoe thrust bearing, coupled with the seal coolers for both stuffing boxes. Provide mechanical seals and an extra seal replacement kit for each pump. In both cases, stuffing boxes must be site-convertible to a packed box. Ensure leakage is no more than 25 cc/hr for a seal life of not less than 25,000 hours. Ensure bearing rating is not less than 100,000 hours (L-10 life) at the point of maximum load, as defined by ABMA 9. Cool sump by indirect coil. Design pump casing 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

Support pumps 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. Provide bases for pump and drive assembly and support complete with drain lip and pitch to a low-point drain. Shop align the complete pump and motor assembly using shims on both the pump and motor. Install pumps on their concrete foundations where shown on the drawings.

2.4.10.3 Pump Couplings

Furnish all pumps with nonlubricated flexible-disk couplings and a coupling guard. Provide spacer type couplings 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, arrange each boilerfeed pump for continuous operation and furnish 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. Use feedwater regulating valve to maintain a constant feed-pump discharge pressure. Provide an internal-pilot-operated piston valve, single-seated, V port or tapered plug, and adjust 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.

Construct valve body of bronze with renewable disks and seats of hardened stainless steel and design for a working pressure of not less than [1.72] [_____] MPa [250] [_____] psig. Provide a position indicator with the valve.

2.4.10.5 Pump Shutoff Valve

Fit each pump 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, provide an automatic recirculating bypass valve unit 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

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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.
****

Provide steam turbines for boilerfeed pump to operate the pump properly in a steam pressure range of [_____] kPa psig with steam back-pressure of [_____] kPa psig. Turbines must have horizontally-split, two-piece, centerline supported casings, water-cooled bearing cases with ring-oiled, babbitt lined, bronze packed sleeve bearings. Equip turbines 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. Provide turbines conforming to NEMA SM 23.

2.4.10.7 Electric Motor Drives

Select electric motors for continuous duty and nonoverloading characteristics suitable for the power characteristics available. Provide [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] motors. Provide magnetic, reduced voltage start type motor starter with [general-purpose] [weather-resistant] [water-tight] [dust-tight] [explosion-proof] enclosure.

2.4.10.8 Shop Hydrostatic Testing

Subject all pumps to shop hydrostatic testing. Subject one pump in each service 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. Make performance tests in accordance with API STD 610. Procedures and results are subject to the approval of the

Contracting Officer.

2.4.10.9 Control Location

Start boiler feedwater pumps through the combustion equipment/boiler panel, manual/automatic switch.

2.4.11 Condensate Pumps

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

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Condensate pumps must be horizontal, end-suction, single-stage, centrifugal, motor-driven pumps. Provide casing of proper material for the pressure involved, and provide bronze or Monel trimmed pumps, with stainless steel shafts or shaft sleeves, and bronze impellers. Provide pumps with stuffing boxes. Lubricate by splash oil with oil level sightglass provided. Pumps are subject to the same tests specified for the boiler feedpumps. Install condensate pumps on suitable concrete foundations. Provide each pump with 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 must not exceed [_____] meters feet, and the pumps must 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 must be water-or oil-cooled and self-aligning. All necessary vents, drains, petcocks, oil sight glasses, etc., and the proper packing materials for mixed condensate and makeup water service must be of the manufacturer's highest standards. Provide factory assembled horizontal pumps to the motor drives on a rigid structural steel or cast iron baseplate. Connect each pump directly 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

Provide amply sized condensate pump motor drives to handle the pump power with low discharge heads and do not exceed 1750 revolutions per minute (rpm). Supply ball bearing motors of totally enclosed fan-cooled construction for the power characteristics available. Provide condensate pump motors with a magnetic across-the-line starter equipped with thermal overload protection. Locate starters in the motor control center.

2.4.11.3 Condensate Pump Auxiliaries

Provide condensate tank and pumps complete with all piping, suction strainers, suction and discharge valves, check valves, and fittings

required for an integrated unit. Make provisions in the pump suction and discharge lines for thermal expansion and vibration isolation. Use factory assembled piping. Furnish all pumps with isolating valves on suction and discharge, suction strainers, startup strainers, silent check valves, and recirculating piping. Arrange pumps with bypass line and orifice in accordance with manufacturer's specifications to recirculate pumped fluid. Provide all controllers, alarms, gauges, sight glasses, control valves, etc., with shutoff and/or bypass valves as required for maintenance of the system while in operation.

2.4.12 Emergency Interlock

Provide emergency interlocks 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 must act automatically.

2.4.13 Calorimeter

Provide a calorimeter connection in the steam main and provide a flange nozzle between the stop gate and the nonreturn valve to permit release to atmosphere when testing the boiler at maximum capacity. Equip the flanged nozzle with blind flange and gaskets.

2.5 CONDENSATE TANK AND ACCESSORIES

2.5.1 Condensate Tank

Design condensate tank for a working pressure of 103 kPa 15 psig and conform to ASME BPVC SEC VIII D1. Provide tank with a storage capacity equal to or greater than indicated and install complete with all piping and accessories. Factory prime condensate tank with the manufacturer's standard paint.

2.5.2 Feedwater Makeup Valve

Provide a float-controlled valve for emergency feedwater makeup to the tank. Operate valve by a float-control mechanism connected to the surge tank and maintain a suitable minimum water level in the tank. Locate float box outside the tank and ensure connections are properly valved to permit blowdown and servicing.

2.5.3 Overflow Trap

Install an overflow trap designed for the service with the condensate tank. Operate the trap to prevent the water level in the surge tank from rising above a predetermined point by automatically discharging the excess water and design to prevent the escape of steam and air.

2.5.4 Tank Connection and Controls

Provide tank 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. Provide tank with a low-level alarm and pump shutoff and high-level alarm. Provide alarms consisting 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

Provide tank consisting of butt fusion welded steel plate with a maximum diameter of [_____] and a maximum straight side length of [_____]. Test tank under pressure to assure no leaks. Make provisions in the tank for all connections. After fabrication, clean the interior of the tank of all mill scale, oil, and weld splatter and then coat with a baked-on phenolic lining or approved equivalent material that is suitable and guaranteed for continuous immersion in condensate and softened water from a sodium zeolite softener at 99 degrees C 210 degrees F. Provide shop assembled condensate tank and check for proper fit of accessories. Determine what items should be removed and ship loose for field assembly. Erect condensate tank in a horizontal position.

2.5.7 Condensate Tank Trim

Provide condensate tank with 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. Provide all controllers, alarms, gauges, sight glasses, control valves, etc., with shut off and/or bypass valves as required for maintenance of the system while in operation.

2.5.8 Additional Requirements

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

2.6 HEAT EXCHANGERS

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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. Design, fabricate, test, and stamp heat exchangers in accordance with ASME BPVC SEC VIII D1. Additionally, meet the requirements of HEI 2623. Ensure closed feedwater heater designs meet the requirements of HEI 2622. Provide all heat exchangers with relief valves as required by ASME BPVC SEC VIII D1 and HEI 2623 and design for a working steam pressure of [586] [_____] kPa [85] [_____] psig. [Design heat exchangers using service water to have the service water inside the tubes.] [The exchangers must 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. Use carbon steel materials of construction, except use service water side materials that reflect the service water available. When the water quality permits, provide stainless steel tubes in accordance with ASTM A249/A249M, Grade TP 304; provide all carbon steel for the remainder of the tube side. When the service water is known to contain chloride levels harmful to stainless steels, provide 90-10 Copper-Nickel tubes in accordance with ASTM B111/B111MAlloy 706; provide the following for the remainder of the service water side: 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, use a split-ring floating-head design.

d. Provide heat exchangers, steam-to-heat domestic water or other fluids such as glycol-water mixtures or fuel oil with the steam in the shell side. Provide exchangers of U-tube designs with bolted full-diameter channel covers to facilitate tube maintenance as required. Ensure the tubesheet is the full diameter to match the shell flange and has sufficient threaded holes so that a shell hydro test may be applied without the channel in place. Materials of construction must 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. Provide fuel oil heaters with carbon steel tubes in accordance with ASTM A179/A179M and furnish in the stress relief annealed temper with the U-bends stress relieved after bending.

e. Use feedwater heaters consisting of all-welded construction with bolted full diameter channel covers to facilitate tube maintenance as required. Ensure the channel barrel is integral with the tubesheet and has an internal pass partition bolted cover design that is readily removable when the channel cover is removed. Pass partitions that are sealed with a gasketed groove in the channel cover are prohibited. Use carbon steel for all materials of construction except the tubes. Provide pressure boundary material in accordance with ASTM A516/A516M, Grade C, when plate material is required, or ASTM A350/A350M when forging material is required. Provide shroud plate material for desuperheating and subcooling zones in accordance with ASTM A285/A285M, Grade C. Provide stainless steel tubes in accordance with ASTM A688/A688M, Grade TP 304, stress relief annealed temper with U-bends stress relieved after bending. Coat shell on the outer surfaces with an approved rust-inhibiting paint. Design coils for a working pressure of [_____] kPa psig. [Employ a heat exchanger 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

Install deaerating feedwater heater, of the size and capacity indicated, where indicated. Provide steel plate shell. [Provide a corrosion-resistant steel tray system for a Type I unit.] Provide [copper] [corrosion-resistant steel] floats. Provide a [loop seal] [float-controlled overflow trap] overflow control. Provide a heater with a pressure relief valve, thermometers, pressure gauge, and oil separator. Install a combination temperature-pressure recorder for each feedwater heater. Take steam pressure readings from the shell, and the temperature bulb must [indicate] [record] the temperature of the feedwater after it passes over the trays and sprays. Provide an alarm 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. Operate system by an approved type of external electric float switch connected to the tank. Mount signal lamp and bell where directed. Provide float operator for the deaerator level control valve 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

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NOTE: In general, use tray system for fluctuating loads and the spray system for steady loads.
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Provide spray type heater with spray valve vent condenser in accordance with ASME BPVC SEC I and design for [_____] kPa psig working pressure. Deaerator must be ASME stamped. All steel plate used in construction of the heater and storage tank shells must be ASTM A285/A285M Grade C. Where thickness makes it desirable, ASTM A515/A515M or ASTM A516/A516M steel may be used as appropriate. Include at least 2.0 mm 1/16 inch corrosion allowance over the calculated ASME Code thickness. Test heater and storage tank at a pressure 50 percent in excess of the design pressure. Design heater 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. Provide heater 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. Provide heater with an internal vent condenser fabricated entirely of stainless steel which includes a vent hood and vent orifice or separate vent valve. Heater section must contain spring-loaded spray valves mounted in a stainless steel water box and a stainless steel vent condenser. Construct spray valves of 18/8 stainless steel and provide a constant angle of spray at ranges from 10 to 150 percent of capacity. Provide hydraulically balanced valves, thus requiring no guides that might bind, scale, or otherwise clog. Locate spray valves to allow their servicing, inspection, and removal. Maximum tank dimensions are [_____] outside diameter. Construct internal parts of the deaerating heater, including baffles, distributing nozzles, vent pipe, and vent collecting hood of heavy gauge stainless steel. Provide a drawing showing the "internal" construction of the heater with each bid. Include an internal sparger tube for chemical treatment injection with the deaerator. Provide boiler feedwater pump suction nozzle incliding a vortex breaker. Provide deaerator with all of the connections shown on the drawings, as a minimum.

2.7.3 Deaerator Trim

Provide deaerator 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. Provide pressure gauges conforming to ASME B40.100 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. Adjust reducing valve to maintain the desired terminal pressure, regardless of fluctuations in the initial pressure. Provide single-seated, spring loaded valves that are quiet in operation, and guaranteed not to stick. Valve body 65 mm 2-1/2 inches and larger must be cast steel; 50 mm 2 inches and smaller must be of bronze. Provide valve trim consisting of stainless steel, Monel metal, or approved corrosion-resisting material. Ensure all parts subject to wear are readily replaceable. Provide valves with seats and plugs faced with cobalt tungsten carbide mixture, or made of heat treated stainless steel or high chromium steel guaranteed to resist erosion. Provide seal and plug facing with a Brinell hardness of no less than 450. Install valve with a strainer, a bypass, [safety valve on deaerator] as indicated. Connect sensing line to the steam space in the deaerator. Size control valve for a minimum capacity of [_____] kg/hour lb/hour at design conditions, but do not exceed a capacity greater than [_____] kg/hour lb/hour for the same conditions. Select valve trim 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 must 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. Provide testing outfit conforming to ASTM D888, complete with chemicals for 100 tests. Provide all controllers, alarms, gauges, sight glass, control valves, etc., with shutoff and/or bypass valves as required for maintenance of the system while in operation.

2.7.5 Performance Guarantee

Provide that the deaerator:

a. Is 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. Is of sufficient design to reduce free carbon dioxide to zero.

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

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

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

2.8 PIPING

Unless otherwise specified, provide pipe and fittings conforming 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: Conform to requirements of UFC 3-410-01 or UFC 3-410-02.
****

Provide a feeder unit for each boiler. Provide automatic proportioning, shot, or pump type chemical feeders. Provide all appurtenances necessary for satisfactory operation. Base size and capacity of feeder upon local requirements and water analysis. Install feed piping 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

Furnish chemical feed pumps and tanks as a package with the pumps mounted on and piping connected to the tank. Provide pump cylinders, plungers, ball check valves, and check valve bodies consisting of corrosion-resistant materials suitable for the chemicals being pumped. Ensure volumetric accuracy of the pumps is within one percent over the range indicated. Adjust pump capacities by positioning the crankpin with micrometer setscrews. Stroke length scale must be divided in percentage graduations engraved on the scale. Cylinders must be replaceable for increased or reduced pressure or capacity ranges. Provide drive motors that are suitable for the electric power available and that have drip-proof enclosures. Drive each pump by a separate motor. Make tanks of polypropylene and mount on legs. Provide tanks with filling and drain connections, and gauge glass. Furnish each tank 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 must have a hinged cover. Tank bottom must be dished concave to a radius equal to the diameter of the tank. Units must be for phosphate or caustic feed and sulfate feeding. Provide motor-driven agitator. Design the pump 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.

****

Provide a complete sodium zeolite cycle water softening system as specified in Section 22 31 00 WATER SOFTENERS, CATION-EXCHANGE (SODIUM CYCLE). Size equipment to run 24 hours before regeneration when operating at a sustained softening rate of [_____] L/second gpm. Provide tanks complete with cover and design 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. Install an automatic control system for each boiler in accordance with the manufacturer's recommendations. Provide all locally indicating instrumentation and controls and install 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, install controls in accordance with the control manufacturer's instructions. Locate automatic controllers on the control room panel as specified.

b. Operate equipment either pneumatically, electrically, or electronically. Provide pneumatic control systems conforming to CAGI B19.1. Install air filter regulator sets at each control valve and transmitter in the system. Provide dual type master air filter regulator set on the control panel where one side can be cleaned and repaired while the other is in operation. Protect exterior control air piping and devices from freezing by use of a regenerative desiccant dryer. Provide each system with a selector switch or other means to permit manual control of the firing rate when required. Electrical control devices must be rated at 120 volts and connected as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Wire operating and limit controls to interrupt the ungrounded circuit conductor.

c.[Steam and energy generating equipment must include instrumentation and sufficient metering for accountability interface with a future Energy Monitoring and Control System (EMCS).] If pneumatic controls are provided, use duplex air compressors with a drier between the compressors and tank. Size air compressor units to run no more than 60 percent of the time when all controls are in service.

2.10.1 Positioning Type

Provide positioning type control equipment 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. Maintain combustion efficiency without appreciable manual adjustment. Provide system 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. Connect master transmitter to the main steam header where the steam pressure is to be controlled. The signal transmitted from this point to the master controller must be a function of steam pressure. On multiple boiler installations, provide a means to base load on individual boilers while on automatic, and control each boiler unit individually. Make provision on the control system for adding on other boilers to the system with only minor wiring or piping changes on the panel. Provide a manual-to-automatic station and indicator on the control panel for each automatic controller that will provide for selecting either automatic control or manual control and also will provide for manual operation. Arrange manual controls 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. Provide manual control station complete with all necessary indicators to facilitate changing from automatic control to manual control and vice versa. Mount controllers on the instrument panel which indicate and control measurement in the areas shown, and have a manual adjustment on the front of the instrument.

Install controllers complete with wiring or piping between the controller, transmitter, and the final control device.

2.10.2 Equipment

Provide control equipment and instruments including 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. Provide control system in accordance with FM APP GUIDE. Mount operating controls and instruments on one or more free-standing control panels conveniently located and place 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. Interlock automatic-control circuit systems and manual switches 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, direct gases through the boiler. As long as maximum energy is required, make this the mode of operation. If less than full energy production is required, modulate gas flow to reduce steam production by the boiler. Maintain specified steam pressure within plus or minus 1 pound by means of a pressurestat and a boiler-draft regulator. Provide pressurestat with necessary relays to 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

Size power units for the movement of dampers to operate the device to be positioned, and mount so that a rigid mechanical connection to the device being operated can be used. Ensure units automatically close in the event of failure of the operating medium. Manual operation of the controller must not necessitate disconnecting the linkages during power failure or other emergency. Include position switches on fuel and air-drive units for interlock with safety systems. Place retransmitting devices 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, use oil immersed gear trains on the units.

2.10.5 Draft Fan Control

Provide induced draft centrifugal fans with outlet dampers [and variable speed control]. [Provide axial propeller fans with variable propeller pitch control.] Provide means for operating the induced draft fan for 15 minutes after the combustion equipment has ceased operation.

2.10.6 Soot Blower

Mount all controls, lights, switches, and indicators provided for operation of soot blower on the control cabinet.

2.10.7 Boiler Limit Controls

Provide limit controls and interlock switches conforming to UL 353.

2.10.7.1 Low-Water Cutoffs

Provide two low-water cutoffs 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. Provide manual reset type secondary interlock.

2.10.7.2 High-Pressure Limit Switch

Provide a high-pressure limit switch to shut down the combustion equipment when steam pressure exceeds the preset safe limit. Provide this equipment in addition to the operating controls.

2.10.7.3 Draft Loss Interlock

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

2.10.8 Instrument Control Panel

Provide a NEMA ICS 6 Type 4 unit prewired panel, of steel, weathertight, and conforming to UL 50. Unless enclosed in a booth or separate room, also construct the panel to protect the instruments and controls from dust. Locate boiler control panel next to the control panel for the combustion equipment, or one panel may be used for both. Wire all instrument connectors and cable termination connectors in the factory by the instrumentation fabricator. Flush mount all controls, instruments, and other equipment at the factory and assembly-test before shipment. Furnish a lock and two keys . Identify all controls and instruments with nameplates. [Provide a thermostatically controlled heater to prevent condensation.]

2.10.8.1 Panel Details

a. Size instrument and control panel to contain all controls, instruments, gauges, and meters. Provide freestanding panels with a faceplate of no less than 7 mm 3/16 inch steel, properly reinforced, and finish with the manufacturer's standard finish coating. Mount units flush on the panel as far as practicable. Flush mount all controls, instruments, and other equipment, fit each neatly into a cutout, and completely cover the cutout and any mounting screws or bolts.

b. Enclose back of the panel with sheet metal and with adequate removable access panels or doors for maintenance and removal of any unit without interfering with other units. Provide proper latching equipment and hardware. Identify each recorder, indicator, and control unit with nameplates securely fastened to the panel. Provide nameplates

consisting of black over white laminated plastic with the lettering penetrating the black surface to expose the white. Provide panel with continuous rapid-start fluorescent light fixtures mounted with reflectors providing suitable shielding to illuminate all controls, instruments, gauges, and meters.

c. Terminate all field piping connections in one bulkhead-mounted manifold, located to conform with the installation requirements of the system. Terminate all field electrical wiring in a color-coded terminal strip to conform with the installation requirements of the system. Ensure all electrical tubing or piping connections to controls, instruments, or other devices on the panel are inside the panel and not visible from the panel front. Provide a suitable plug-in strip in the rear of the panel for any required plug-in electrical connections of the instruments. Install all necessary transformers, separate relays, switches, and fuses in a fully enclosed junction box. Use a fused safety switch to serve the 120-volt power supply required for control circuits.

d. If a pneumatic control system is provided, 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. Provide panel mounted controllers and indicators specified or required and test at the factory complete with relays, transformers, switches, wiring, valves, piping, and other appurtenances. Color-code all wiring and piping within the panel or identify otherwise.] Isolate thermocouple and low energy signal conductors completely from power and alarm conductors, subject to approval by the Contracting Officer. Provide visual and audible alarms to protect personnel and equipment.

2.10.8.2 Recorders

Provide servo-mechanism type or multiple-pen type recorders. Provide [circular] [strip] chart. Minimum chart width is 100 mm 4 inches. Accuracy must be plus or minus 1/2 percent. Provide each pen with a separate scale calibrated in engineering units. Chart drive must be 120 volts ac. Provide one year's supply of chart paper. Make record in ink on a [24-hour] [31-day] chart driven by an electric clock mechanism. Make each recorder point with a different color ink. Install recorders complete with all necessary wiring or pipe between the recorder and the transmitter in the boiler room. Ensure recorders mounted on the instrument panel record and indicate measurement in the areas shown.

2.10.8.3 Panel Display

Include visual indication of the various modes of the main system components (i.e., damper positions, I.D. fans). As a minimum, display the following parameters 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

Furnish all field items with a permanent metal tag suitable for tag number or service identification; include back of panel items in this category. Install wires and cables without joints or splices except at terminal points. Identify wires at both ends by labels.

2.10.8.5 System Diagram

Furnish laminated, color-coded system diagram mounted on the control panel indicating all system components and location of all sensors and alarm points.

2.10.9 Pilot Lights

Assemble pilot lights 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. Integrate components through appropriate electro-mechanical devices with push-to-test indicating lights. Provide industrial oil-tight construction 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

Provide electric synchronous motor type clock. Provide clock for surface mounting and suitable for operation on 115-volt, 60-Hz single-phase electric service. Provide clock with 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. Seal the motor gear train 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.

****

Mount an annunciator system on each control panel. Visual signals must be backlighted nameplates for each point. Provide a common audible alarm

signal and a common acknowledge push button for each control panel. Include a common alarm-silencing relay 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 must be nominal 70 mm 2-3/4 inches high by 75 mm 3 inches wide in translucent white acrylic plexiglass and engrave all nomenclature on front surface in black lettering. Mount flasher module and prewire with silence and test pushbuttons. Ensure alarm points and window engraving are 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

Provide steam flowmeters to measure the steam flow from each boiler and each main steam header outlet. Also provide flow meters to measure feedwater flow to each boiler. Provide flange-mounting type nozzles and orifice plates made of stainless steel. Provide orifice plates of the square edge, concentric, paddle type designed for flange taps. Provide condensate pots for steam service. Design meters to accurately measure saturated steam at a gauge pressure of [_____] kPa psi. Provide direct connected meters of the indicating, recording, and integrating type with electric chart drives. Provide dust-tight metallic or plastic instrument cases, finished in manufacturer's standard black, and arranged for flush-panel mounting. Ensure flow recordsare in thousands of kg pounds per hour on an ink chart recorder. Totalize steam flow in kg pounds by an integrator having no less than a six-digit counter. The installation of stainless steel orifice plates must include shutoff valves, equalizing valves, and blowdown valves. Provide each meter with a guaranteed

accuracy of plus or minus 1/2 of 1 percent while operating at 20 to 100 percent of capacity. Install steam-flow orifices and associated steam piping in accordance with the manufacturer's recommendations and label 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

Size orifice plate to produce a 25.42 kPa 100 inch W.G. pressure differential at the rated flow of the meter as shown on the drawings. Provide orifice plates that are 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 must be made by the manufacturer under ASME MFC-3M, or equivalent by Spink or American Gas Association. Drill a weep hole in plates for steam or condensibles service when installed in horizontal meter runs.

2.10.12.2 Flow Transmitters

Provide pressure differential and transmitting components with 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. Ensure span range, and working pressure are as shown on the drawings. Install transmitters 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.

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Provide differential pressure type, Venturi style flow meters for boiler feedwater measurement. Provide pound-ratedVenturi flow tubes with a series of nozzles around the inner surface to sense and average the

velocity head. Ensure tubes 150 mm 6 inches and larger are flanged and install smaller tubes between welded neck flanges. Provide smaller flow tubes consisting of corrosion-resistant steel and flanged tubes with corrosion-resistant steel throat inserts. Metering must be for water flow [and feedwater temperature]. Mount receiver for each boiler on the boiler instrument panel. Equipment must 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 must match other panel components in appearance and must indicate water flow in [_____]. Where indicating feedwater meter only is utilized, provide a companion indicating feedwater temperature receiver.

2.10.13.2 Indicating, Recording, and Integrating Receivers

Provide indicating, recording, [and integrating] meter receivers. Furnish in a dust-tight metallic or plastic case finished in manufacturer's standard black finish and arrange for flush panel mounting. The indicator must show with a pointer the rate of water flow. Record the flow, in thousands of kg pounds per hour, in ink on a 24 hour, 300 mm 12 inch diameter, equally graduated circular chart driven by an electric clock mechanism. Provide sufficient blank charts and ink for 400 days of operation. Also record boiler feedwater temperature in degrees C and degrees F degrees F on the same chart. [Totalize water in kg pounds by an integrator having no less than a six-digit counter.]

2.10.14 Blowoff Sample Cooler

Provide 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. Connect cooler to a header and valve so the operator can obtain a sample of properly cooled blowoff from any boiler as desired. Properly support cooler and provide a brass or bronze sampling cock with lever or compression handle. Provide 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.

2.10.15 Temperature Indicators

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

2.10.15.1 Thermometers

Provide thermometers conforming 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. Do not use Mercury in thermometers. Provide thermometer consisting of 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. Install thermometers so as to be easily read from the operating floor.

2.10.15.2 Thermocouples

Use thermocouples suitable for continuous operation and control at temperatures up to 1260 degrees C 2300 degrees F, accurate to 0.75 percent, and long enough to be inserted 150 mm 6 inches into the boiler. Provide thermocouples conforming to ASTM E230/E230M, Type K 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. Supply one hundred feet of 16-gauge compensating lead wire with a weatherproof braid for connecting the thermocouple to the instrument. Installed unit must indicate gas passage temperatures and control combustion equipment operation. Transmit temperature to the instrument in the control panel as shown.

2.10.15.3 Indicating, Recording Pyrometers

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

2.10.16 Draft Indicator and Control

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

2.10.17 Pressure Gauges

Provide heavy-duty industrial type gauges 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. Install pressure gauges 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. Install pressure gauge with a [250 mm 10 inch] [300 mm 12 inch] dial face on each boiler. Install gauges to be accessible and easily read from the operating floor. Equip gauges with integral or separate siphons, and pulsation dampeners and connect by brass pipe and fittings with shutoff cocks. Where pressure reducing valves are used, place upstream and downstream gauges close to the pressure reducing assembly, but connect approximately 3 m 10 feet therefrom. Operating ranges of the gauges must be approximately twice the normal operating pressure.

2.10.17.1 Pressure Gauges (Panel)

Furnish and install[three] [_____] 150 mm 6 inch dial size, phenol or brass, black enamel finished case, gauges to indicate main steam, boiler feedwater, and deaerator makeup. Provide Bourdon tube style gauges with back connections and white dials with black lettering. Equip steam gauges with siphons and ensureall gauges have shutoff valves at the panel. Make panel entry through bulk-head connectors located in the upper part of the panel. Gauge accuracy must be at least 1/2 of 1 percent and normal readings must be approximately 50 to 75 percent of full scale reading. Label gaugesas follows:

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)

Furnish and install [_____] 115 mm 4-1/2 inch dial size, phenol or brass, black enamel finished case, gauges for the services shown below. Provide Bourdon-tube style gauges with bottom connections and white dials with black lettering. Equip steam gauges with siphons and install all with shutoff valves. Gauge accuracy must be at least 1/2 of 1 percent and normal readings must 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

Tag Number	Service
PI-[_____]	Condensate Pump No. 2, Suction Pressure

Provide gauges conforming to ASME B40.100, of pressure detecting class, single, Bourdon tube style, and suitable for detecting air pressure. Ensure gauges are remote reading to the control panel.

2.10.18 Feedwater Temperature and Pressure Recorder

Install feedwater temperature and pressure recorder on the boiler plant central metering panel to record the deaerated feedwater temperature and the pressure of steam space in the deaerating heater. Provide recorder as specified. Provide unit with interconnecting tubing and separable sockets for elements located in the feedwater heater. Totally enclose electrical connections. Provide accuracy within plus or minus 1 percent of the chart range.

2.10.19 Condensate Flowmeter

Furnish and install a 40 mm 1-1/2 inch in-line disk meter in the makeup line to the deaerator. Provide meter consisting of a bronze housing, stainless steel trim, and disk suitable for an operating temperature of 105 degrees C 220 degrees F. Equip meter 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

Furnish special tools only and 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. Furnish small hand tools with a suitable cabinet, mount where directed. Also furnish the following tools.

2.11.1 Tube Cleaner

For water-tube boiler installations, provide a water-driven cleaner with three rotary cutters, the necessary length of armored water hose, valves, and all other appurtenances necessary for operation. Provide tube cleaner for each size of watertube in the boiler, with one extra set of cutters for each size cleaner. Provide necessary valves and fittings 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. Arrange piping such that one boiler feed pump may be used to operate the cleaner without interfering with normal operation.

2.11.2 Tube Brush

Provide tube brush (for fire-tube boiler installations) with steel bristles and jointed handle of sufficient length to clean full length of fire-tubes.

2.11.3 Smoke Pipe Cleaner

Provide cleaner to clean the breaching and smoke connections. Cleaner must have jointed handle of sufficient length to clean breeching and smoke connections without dismantling.

2.11.4 Wrenches and Gaskets

Provide wrenches as required for opening boiler manholes, handholes, and cleanouts. Provide one set of extra gaskets for all boiler manholes and handholes, for pump barrels, and other similar items of equipment. Package and properly identify all gaskets.

2.12 PAINTING AND FINISHING

2.12.1 Preventing Corrosion

Unless otherwise specified, factory paint surfaces of ferrous metal subject to corrosion in accordance with the manufacturer's standard practice. Paint all exposed pipe covering as specified in Section 09 90 00 PAINTS AND COATINGS. Do not paint aluminum sheath over insulation. Protect all metallic materials against corrosion. Where connected to dissimilar metal, protect aluminum by approved fittings and treatment. Zinc coat all parts such as boxes, bodies, fittings, guards, etc., made of ferrous metals, but not of corrosion-resistant steel, 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

Clean 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, to bare metal to remove oil, rust, sand, dirt, fins, spurs, scale, slag, flux, etc., before primer is applied at the factory. External surfaces must be smooth and all edges rounded or beveled, unless sharpness is required to perform a necessary function.

2.12.3 Boiler Coating

Finish boiler with one coat of silicone aluminum heat-resisting (up to 648 degrees C 1200 degrees F) paint. Apply paint directly to clean bare metal surfaces and attain a minimum dry film thickness of 1 mil. After assembly, clean all exposed surfaces of the equipment normally painted in good commercial practice to bare metal and finish 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, clean the surfaces to remove all grease and other foreign matter. Do not apply paint when the temperature is below 10 degrees C 50 degrees F or above 32 degrees C 90 degrees F.

2.12.4 Equipment Coating

Factory finish equipment and component items, when fabricated from ferrous metal, with the manufacturer's standard finish if located within buildings. Items located outside must 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 must 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

Conduct initial capacity and performance tests of factory-assembled boiler components at the manufacturer's plant. Repair or replace any rejected material or equipment 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 coordinate the work of the different trades so interference between conduit, piping, equipment, architectural, and structural work will be avoided. Building design modifications necessitated by the proposed equipment are the responsibility of the Contractor and must be approved before proceeding with the work.

3.2 INSTALLATION

****

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

****

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

3.2.1 Piping

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

3.2.2 Field Painting

****

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.
****

Clean, prepare, and paint all ferrous metals not specified to be coated at the factory as specified in Section 09 90 00 PAINTS AND COATINGS. Paint all exposed pipe covering as specified in Section 09 90 00 PAINTS AND COATINGS. Do not paint aluminum sheath over insulation.

3.2.3 Insulation

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

3.2.4 Foundation

Construct boiler foundation of [21] [_____] MPa [3000] [_____] psi concrete as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE. Set anchor bolts of adequate length to install the boiler accurately. When embedded in concrete, provide anchor bolts with plates welded on the head and protect against damage until the equipment is installed. Provide plates conforming 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 seismic loads as specified in UFC 3-301-01 and Sections 13 48 73 SEISMIC CONTROL FOR MISCELLANEOUS 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. Provide support steel complying with ASTM A242/A242M and fabricate 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

Provide ASTM A307 anchor bolts. Provide anchor bolt sizes and locations as 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.
****

Provide stack support in accordance with NFPA 211, as applicable. Ensure vertical and lateral supports for exterior chimneys withstand wind forces of [130] [_____] km/hour [80] [_____] mph.

3.2.7 Catwalks and Access Platforms

Furnish and install all necessary platforms, ladders, handrails, and stairs needed for safe and efficient operation and maintenance of the equipment. They may be relocated from the wall openings and passageways shown in order to suit the boiler equipment provided. All railings must have 100 mm 4 inch wide toe-board located no more than 6 mm 1/4 inch above the floor level. Construction must conform as close as practical to items indicated. Provide fabrication, materials, and coatings that 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. Furnish and install all control conduit, wiring and/or tubing not specified elsewhere, but required to provide a complete and operable system under this section of the specifications. This includes 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. Provide ASTM B88M ASTM B88, Type K copper with flared cast brass or wrought copper fittings. Provide pneumatic tubing with 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 must be a minimum of 1.245 mm 0.049 inch. The extent, general location, and arrangement of the system must be as indicated. Locate control panels as indicated and place so that operating personnel may effectively monitor boiler operations, but are not in a position that would interfere with those operations. Fit equipment, instruments, piping, wiring, and tubing into the space allotted and allow adequate

clearances for entry, servicing, and maintenance. Install locally mounted instruments 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. Coordinate installation of the instrumentation system carefully with the work of other trades.

3.2.9 Field Tubing

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

3.2.9.1 Tubing Supports

Use PVC-coated expansion metal troughs or epoxy-coated vertical unistrut racks as tubing supports. Do not use elbows, tees, or crosses. Where the trough branches or changes direction, a suitable gap for the transition will be acceptable. Do not support the tubing over the gap.

3.2.9.2 Air Supply

Provide instrument air supply headers as shown. Distribute instrument air through the area at nominally 620 kPa 90 psig. Reduce pressure to that required at the instrument by a local regulator. Furnish and install an air set unit for each instrument that has a pneumatic output signal (e.g., transmitter, transducer, controllers, positioner, and relay). Provide air set units with a filter regulator with integral drip-well and drain cock and output gauge.

3.2.10 Electrical

Perform instrumentation and power-interconnecting wiring as [shown] [recommended by the manufacturer] and as specified in NFPA 70. Terminate all external wiring to the control panels on terminal boards or on devices in the panels. Carry all cable wire and cable runs in conduit or wireways. Run all signal wiring used for alarm or measurement of control circuits 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. Do not feed instruments from lighting branch circuits. Make termination of all wires on instrument binding screws with solderless insulated shoulder ring-tongue lugs of the proper size for the wire and binding screw. Properly and securely crimp lugs to the wire using the tool recommended by the lug manufacturer. Cut off any termination that is made improperly and install a new lug. Strip all wire with an approved stripping tool or in such a manner as not to damage the conductor.

3.2.10.1 Cable Conductor Identification

Permanently attach identification to each wire terminating on a terminal board or binding screw to facilitate maintenance. Identify by means of plastic sleeving with printed markings, permanently attached stamped foil markers, or other approved means. Wire numbers must correspond to wire numbers shown.

3.2.10.2 Relays

Provide industrial relays for interlocking circuits. Ensure contacts and coils are accessible for cleaning and replacement.

3.2.11 Steam Flowmeter Installation

Mount transmitters at the orifice flanges. Slope impulse lines to eliminate liquid or gas pockets. Provide three-valved meter manifolds, except use a five-valve manifold 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. 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, conduct final checking of systems installations and preliminary operation testing and adjustments of all systems in accordance with the manufacturer's recommendations and the requirements of the specifications. Schedule all tests in advance and conduct 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. Indicate the final position of controls in each test report. 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. 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, are subject to a voltage of twice its rated voltage, plus [500] [_____] volts, for a period of not less than [1] [_____] minute. Before testing, disconnect all instruments and operating mechanisms that could be damaged. After the test, the circuit must still register a resistance of not less than 1 megohm at [600] [_____] volts dc. This test applies 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. Simulate unsafe conditions, such as high temperatures, during the tests by reducing the settings for activation of limit and safety controls.

3.4.5 Necessary Temporary Piping

Furnish necessary temporary test piping no less than [100] [_____] mm [4] [_____] inches in diameter. Provide a steam silencer to exhaust excess steam to the atmosphere in the event the boiler load is insufficient to meet the capacity specified. Provide a control valve for exhausting excess steam to atmosphere in a convenient location inside the boiler room.

3.4.6 Test of Deaerating Feedwater Heater

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

3.4.7 Test of Water Treatment Equipment

Test water treatment equipment meeting the requirements specified as to capacity and quality of effluent. Tests for ion exchange units must cover at least two complete regenerations and capacity runs. Boiler water conditioning includes 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. Use approved chemicals and method of treatment.

3.4.8 Hydrostatic Tests

Following erection, test each boiler hydrostatically and prove 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, make hydrostatic tests and prove the system tight under gauge pressures of 1-1/2 times the specified working pressure. Test boilers and inspect the piping connections by an NBBI-commissioned boiler inspector for determining compliance with all requirements in ASME BPVC SEC VIII D1, and supply the Contracting Officer with a certificate of approval for each boiler. Apply shop foam to all seams to detect leaks. Boiler must 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

Perform test for steam purity, in accordance with ASTM D1066, and water level stability simultaneously under the operating conditions specified.

3.4.9.1 Steam Tests

Make steam tests for boiler over [2.07] [_____] MPa [300] [_____] psig, without superheaters, not used for power generation or large turbine drive, on steam sampled in accordance with ASTM D1066, using the conductivity method in ASTM D2186. Do not exceed 30 microhms at 18 degrees C conductivity of the steam corrected for carbon dioxide and ammonia content. Sample 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 in accordance with ASTM D1066 and test in accordance with the conductivity method in ASTM D2186. Do not exceed 4.0 microhms at 18 degrees C 60 degrees F conductivity of the steam corrected for carbon dioxide and ammonia content. Test steam for moisture in accordance with calorimetric method outlined in Part II of ASME PTC 19.11.

3.4.9.2 Water Level Stability Test

Conduct water level stability test first by use of the manual bypass

around the feedwater regulator. Then repeat test using the automatic feedwater regulator. Ensure boiler maintaina 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. Include 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. Do not commence test 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, must be included and approved prior to system startup.

a. Upon completion of installation, subject the boiler and associated equipment and instrumentation 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.] Perform testing in accordance with the test procedures indicated below and 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. Ensure two instruction manuals are available at all times during the tests.

b. Run an efficiency and capacity test 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. Analyze and record combustion gases entering the heat recovery boiler. Record CO, CO2, H2O, O2, N2, HCl, SO2 and temperature. Use water meter in the test suitable for hot water. Ensure efficiency is not less than specified. Ensure maximum moisture content of saturated steam leaving the boiler is as specified. Conduct efficiency and general performance tests on the boilers by a qualified test engineer. Provide 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 before the test. Read all indicating instruments 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, wire brush surfaces in

contact with water 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. Dissolve chemicals in the above proportions or as otherwise approved thoroughly in the water before placing in the boilers. After the specified boiling period, allow the boilers to cool, then drain and thoroughly flush. Clean piping 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. Use approved chemicals and method of treatment.

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. Prepare 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 in typed form, frame and post 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. 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. 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. Include piping layout, equipment layout, and simplified wiring and control diagrams for the system as installed, and other information necessary for equipment maintenance. Also include recommendations for total staffing and job descriptions in the field training. 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 must 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 must 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, must not exceed the temperature limitation specified. Boilers must 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, inspect the boilers for deterioration such as slagged or spalling refractory, warping of parts, and discolored exterior paint.

-- End of Section --