UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2021
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CENTRAL COAL-FIRED STEAM-GENERATING SYSTEM

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CENTRAL COAL-FIRED STEAM-GENERATING SYSTEM
05/20

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NOTE: This guide specification covers the requirements for coal-fired central steam-generating systems.

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).
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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.

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NFPA 329	(2015) Recommended Practice for Handling Releases of Flammable and Combustible Liquids and Gases

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST HB 44	(2018) Specifications, Tolerances, and Other Technical Requirements for Weighing

and Measuring Devices

RUBBER MANUFACTURERS ASSOCIATION (RMA)

RMA IP-1	(2011) Conveyor and Elevator Belt Handbook; 3rd Edition

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC Paint 16	(2006; R 2015; E 2015) Coal Tar Epoxy-Polyamide Black (or Dark Red) Paint
SSPC SP 6/NACE No.3	(2007) Commercial Blast Cleaning

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-301-01	(2019) Structural Engineering

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

30 CFR 1	Mine Safety and Health Administration; Establishment and Use of Official Emblem

UNDERWRITERS LABORATORIES (UL)

UL 296	(2017; Reprint Sep 2020) UL Standard for Safety Oil Burners
UL 726	(1995; Reprint Oct 2013) Oil-Fired Boiler Assemblies
UL 795	(2016; Reprint Sep 2020) UL Standard for Safety Commercial-Industrial Gas Heating Equipment

1.2 SUBMITTALS

****

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

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for

Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

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

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

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Steam-Generating Units; G[, [_____]]
Equipment Erection; G[, [_____]]

SD-03 Product Data

Steam-Generating Units
Spare Parts
Framed Instructions
Welding

SD-06 Test Reports

Tests

SD-10 Operation and Maintenance Data

Steam-Generating Units; G[, [_____]]

1.3 QUALITY ASSURANCE

1.3.1 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. If the need exists for more stringent requirements for weldments, delete the first bracketed statement and delete the welding submittal.
****

[Submit a copy of qualified procedures and a list of names and identification symbols of qualified welders and welding operators, and a

proposed performance test procedure, 30 days prior to the proposed test date, containing a complete description of the proposed test along with calibration curves or test results furnished by an independent testing laboratory of each instrument, meter, gauge, and thermometer to be used in the tests. The test shall not commence until the procedure has been approved. Submit complete plan for water treatment, including proposed chemicals to be used and nationally recognized testing codes applicable to the system, prior to system startup. Piping shall be welded in accordance with qualified procedures using performance qualified welders and welding operators. Procedures and welders shall be qualified in accordance with ASME BPVC SEC IX. Welding procedures qualified by others, and welders and welding operators qualified by another employer may be accepted as permitted by ASME B31.1. The Contracting Officer shall be notified 24 hours in advance of tests and the tests shall be performed at the work site if practicable. The welder or welding operator shall apply his assigned symbol near each weld he makes as a permanent record.] [Structural members shall be welded in accordance with Section 05 05 23.16 STRUCTURAL WELDING. Welding and nondestructive testing procedures are specified in Section 40 05 13.96 WELDING, PRESSURE PIPING.]

1.3.2 Use of Asbestos Products

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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 or gaskets, even though the item is encapsulated or the asbestos fibers are impregnated with binder material.] [Except as provided below, 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. 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.]

1.4 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.

1.5 EXTRA MATERIALS

Submit spare parts data for each 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 replaced

after [1] and [3] years of service.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

2.1.1 Standard Products

Provide materials and equipment which are the standard products of a manufacturer regularly engaged in the manufacture of the products and that essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Equipment shall be supported by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

2.1.2 Nameplates

Each major item of equipment shall have the manufacturer's name, address, type or style, model or serial number, and catalog number on a plate secured to the item of equipment.

2.1.3 Prevention of Rust

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

2.1.4 Equipment Guards and Access

Belts, pulleys, chains, gears, couplings, projecting setscrews, keys, and other rotating parts exposed to personnel contact shall be fully enclosed or guarded. High temperature equipment and piping exposed to contact by personnel or where it creates a fire hazard shall be properly guarded or covered with insulation of a type specified. Items such as catwalks, operating platforms, ladders, and guardrails shall be provided where shown and shall be constructed in accordance with Section [08 31 00 ACCESS DOORS AND PANELS][05 51 33 METAL LADDERS].

2.2 BOILERS

****
NOTE: Specify steam outlet temperature in cases where the boiler includes a superheater.
****

Each boiler shall have the capacity indicated. The equipment design and accessory installations shall permit accessibility for maintenance and service. Boilers shall be designed for a maximum allowable working pressure of [_____] Pa psig with an operating pressure of [_____] Pa psig. Design conditions shall be as follows:

Rated capacity	[_____] kg/hour pounds/hour

Steam outlet temperature	[_____] degrees C degrees F
Site elevation	[_____] m feet
Ambient air temperatures	[_____] to [_____] degrees C degrees F
Reference air temperature	27 degrees C 80 degrees F

The boiler shall be capable of operating continuously at maximum specified capacity without damage or deterioration to the boiler, setting, firing equipment, or auxiliaries. The boiler shall be capable of automatically controlled operation while burning the fuel specified.

2.2.1 Capacity

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

2.2.2 Electrical Equipment

Electric motor-driven equipment specified shall be provided complete with motors and necessary motor control devices. Motors and motor control devices shall be in accordance with Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM including requirements for hazardous area locations. Integral size motors of shall be premium efficiency type in accordance with NEMA MG 1.

2.2.2.1 Motor Ratings

Motors shall be suitable for the voltage and frequency provided. Motors 373 W 1/2 horsepower and larger shall be three phase, unless otherwise indicated. Ratings shall be adequate for the duty imposed, but shall not be less than indicated.

2.2.2.2 Motor Starters

****
NOTE: Where motor starters for mechanical equipment are provided in motor control centers, delete the reference to motor starters.
****

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

solid-state variable-speed controllers may be provided to accomplish the same function.

2.2.3 Boiler Design Requirements

2.2.3.1 Radiant Heating

****

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

Boiler Type	**Maximum kJ/sq meter Btuh/sq ft**
Controlled circulation watertube boilers	**1,419,500 125,000**
Natural circulation watertube boilers	**1,135,650 100,000**
Firetube boilers	**1,135,650 100,000**

****

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

2.2.3.2 Heat Input

The maximum heat input per cubic meter cubic foot of furnace volume shall be [931.5 Megajoules/cubic meter 25,000 Btu/cubic foot with spreader stokers] [1.7 Gigajoules/cubic meter 45,000 Btu/cubic foot with underfeed stokers].

2.2.3.3 Combustion Gas

The combustion gas temperature at the furnace exit shall be a minimum of 38 degrees C 100 degrees F less than the ash fusion softening temperature (reducing atmosphere) of the coal specified.

2.2.3.4 Ash Discharge

[Spreader stoker units with continuous or intermittent automatic mechanical ash discharge grates, or one of the traveling grate type, shall have a maximum loading of 2.2 Mega watts/square meter 700,000 Btuh/square foot of grate area.] [Underfeed dumping grate units shall have a maximum loading 1.4 Mega watts/square meter 450,000 Btuh/square foot of grate, assuming a 10 percent maximum ash content and 1205 degrees C 2,200 degrees F minimum ash softening temperature. The area shall not include side dumping areas.]

2.2.3.5 Radiant Heating Surface

Effective radiant heating surface shall be as specified in ASME BPVC SEC I. For firetube steel firebox boilers it shall be the total water backed area within the furnace boundaries exposed to the flame. The mean circumference shall be used for corrugated crown sheets.

2.2.3.6 Furnace Volume

Furnace volume for watertube or firetube boilers is defined as the cubical

volume between the top of the grate and the first plane of entry into, or between, the tubes. If screen tubes are utilized, they constitute the plane of entry.

2.2.3.7 Boiler Operating Capacity

The boiler shall maintain continuous capacity within the specified range at the specified pressure with boiler feedwater at a temperature of approximately [_____] degrees C degrees F. The flue gas outlet temperature shall be [_____] degrees C degrees F, based on excess air of [_____] percent and carbon loss of [_____] percent at maximum continuous capacity. Moisture in steam and boiler water concentrations shall be in accordance with ABMA Boiler 402.

2.2.3.8 Boiler Output Capacity

Output capacity of the boiler shall be based on tests of the boiler as a unit.

2.2.3.9 Boiler Markings

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

Each boiler shall be stamped with:

a. Maximum continuous capacity in Watts Btuh.

b. Radiant heating surface in square meters feet.

c. Total heating surface in square meters feet.

d. Furnace volume in cubic meters feet.

e. Boiler unit design maximum allowable working pressure.

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

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

2.3 BOILER DETAILS

2.3.1 Packaged Steam-Generating Units

Submit manufacturer's design data and structural computations for walls, roof, foundations, and other features, for specialty type of construction. Include design data for lateral forces that may be encountered due to wind loads and seismic forces.

Submit [6] [_____] complete copies of operating instructions, prior to the training course, outlining the step-by-step procedures required for system startup, operation, and shutdown. The instructions shall include the manufacturer's name, model number, service manual, parts list, and brief description of all equipment and their basic operating features. Submit [6] [_____] complete copies of maintenance instructions, prior to the training course listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides. The instructions

shall include piping layout, equipment layout, and simplified wiring, and control diagrams of the system as installed.

2.3.1.1 Firebox Type (for Boiler Capacities Less Than 2.9 Mega watts 10,000,000 Btuh)

Units shall be furnished complete with coal burning equipment, [fly ash collector,] brickwork, insulation with steel jacket, safety and operating controls, forced- and induced-draft fans, low water cutoff and alarm, and other required appurtenances. The unit shall be complete, self-contained, fully automatic, and ready for service upon completion of utility connections except that firing equipment, safety and operating controls may be packaged separately from the boiler, fully assembled, factory wired, and completely ready for field mounting. The firebox boiler shall be of the watertube or firetube type in conformance with ASME BPVC SEC I. Control panel shall be prewired and totally enclosed. Over-fire air jets shall be provided for furnace turbulence. Positioning controls shall be provided. [The boiler shall be equipped with soot blowers.]

2.3.1.2 Watertube, Waterwall Type (Boiler Capacities Over 2.9 Mega watts 10,000,000 Btuh)

Except as modified, the steam-generating unit shall comply with the requirements of ASME BPVC SEC I. Steam generating unit shall be furnished complete with stoker, [fly ash collector,] forced- and induced-draft fans, control and instrument panel with limit and automatic controls, soot blowers, over-fire air system feedwater regulator, low water cutoff and alarm, feed piping and all other fittings, auxiliaries, and appurtenances necessary for safe and efficient operation. The steam generator shall be factory fabricated and [assembled on a steel foundation or foundations] [top supported].

2.3.2 Watertube Boilers

Watertube type boilers shall be of the [site assembled] [shop assembled] type with either two or three drums and arranged to suit the fuel burning equipment specified. Boilers shall be capable of continuous operation at the indicated capacity.

2.3.2.1 Drums

Drums shall be steel plate, fusion welded in conformance with ASME BPVC SEC I, including stress relieving and x-raying of welded seams. The main steam drums shall be of sufficient size to accommodate steam separators and drum internals with provisions and space for accomplishment of maintenance. Baffling shall be provided to separate the steam from the water in the drum and to maintain a stable water level under a fluctuating load. Variations in normal water level shall not exceed 50 mm 2 inches, with an increasing load change of 20 percent of rated capacity per minute. Steam separators shall be provided to deliver saturated steam with maximum specified moisture content. Each drum shall have two 304.8 x 406.4 mm 12 x 16 inch elliptical manholes, with the exception of the mud drum which shall have at least one 304.8 x 406.4 mm 12 x 16 inch elliptical manhole. Each manhole shall have cover, yoke, and gaskets.

2.3.2.2 Tubes

Tubes shall be not less than 50 mm 2 inches in diameter, shall be electric welded or seamless steel, and shall be connected to the drums and headers

by expanding into bored tube seats. Boilers shall have water-cooled furnace walls of a design suitable for the application. Lower header of sidewalls shall be round design with tubes welded to header stubs. Each waterwall header shall have enough supply and riser tubes to ensure that no portion of the waterwalls will become water starved at maximum capacity.

2.3.2.3 Baffles

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

2.3.2.4 Access Doors

Access doors in sufficient number, of adequate size, and properly located shall be provided for cleaning, inspection, and repair of all areas in the complete assembly. Doors shall be gas-tight and interior surfaces exposed to direct radiation and high temperatures shall be lined with approved refractory material to prevent excessive heat losses and warping of doors. Doors too large or bulky for hand removal shall be hinged. At least one observation port with cast-iron cover shall be provided on the front and rear wall of the furnace.

2.3.2.5 Miscellaneous Pipe Connections

Miscellaneous pipe connections shall be provided for steam outlet, safety valves, feedwater, feedwater regulator, water column, blowoff, steam supply to soot blowers, steam gauge and vent, continuous blowdown, continuous chemical feed, and instrument connections. Boilers shall be provided with necessary jets for furnace turbulence, the number and arrangement of which shall be as recommended by the boiler manufacturer. Soot blowers shall be provided, if required by the manufacturer. A suitable smoke outlet with steel frame, damper, and damper shaft shall be provided. Damper shall have external high temperature roller or ball bearings at both ends of the shaft, and shall have a suitable operating arm and rod.

2.3.2.6 Superheater Design

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

****

The design of the superheater shall be such that at any given load, and to the extent feasible, all elements have the same outlet temperature. The superheater tube and support materials shall be chosen so that with any reasonably expectable excess air and the worst expected unbalance in air, steam, and fuel distribution, there is an ample and conservative margin of safety to prevent damage by overheating or corrosion to the components. Pad-type permanent thermocouples shall be installed on superheater tubes in sufficient number and so located as to indicate the variation in, and maximum value of, the tube temperature across the furnace width. The thermocouples shall be located outside of the gas stream. The superheater outlet header shall be capable of absorbing the reactions from the main steam piping. The superheater terminals shall be extended sufficiently clear of the boiler walls to facilitate connecting thereto. Any superheater piping must be extended beyond the boiler front wall line, 900

mm 3 feet beyond casing. Header penetrations through the casing shall be minimized. Adequate superheater piping to mount the safety valves shall be provided. The design shall be such as to minimize external corrosion on the superheater and reheater due to molten slag or fouling. The location of headers in the gas stream shall be minimized. Spray desuperheaters shall be complete with thermal sleeves of sufficient length to prevent droplets of water from coming in contact with the hot wall of the pipe. The sleeves shall be arranged for attaching securely to the pipe, but in a manner that will permit differential expansion.

2.3.2.7 Boilers and Firing Equipment

Boilers and firing equipment shall be supported from the foundations with structural steel independent of all brickwork. Boiler supports shall permit free expansion and contraction of each portion of the boiler without placing undue stress of any part of the boiler or setting.

2.3.3 Boiler Settings

2.3.3.1 Boiler Material

Materials shall conform to the following:

2.3.3.1.1 Firebrick

ASTM C27, class as recommended by the boiler manufacturer.

2.3.3.1.2 Insulating Brick

ASTM C155

2.3.3.1.3 Castable Refractory

ASTM C401. The minimum modulus of rupture for transverse strength shall not be less than 4.1 MPa 600 psi after being heat-soaked for 5 hours or more at a temperature in excess of 1371 degrees C 2,500 degrees F.

2.3.3.1.4 Mortar, Air-Setting, Refractory

As recommended by the boiler manufacturer.

2.3.3.1.5 Brick, Common

ASTM C62

2.3.3.1.6 Galvanized Steel Sheets

ASTM A659/A659M, ASTM A653/A653M. Gauges specified are manufacturer's standard gauge.

2.3.3.1.7 Uncoated Steel Sheets and Strips, Low Carbon

ASTM A36/A36M. Gauges specified are manufacturer's standard gauge.

2.3.3.2 Firebox, Packaged Type

Boiler refractories and insulation shall be installed to permit free expansion without placing undue stress on the boiler or refractory. Insulation and jacket shall provide a casing temperature not exceeding 77

degrees C 170 degrees F in an ambient temperature of 38 degrees C 100 degrees F with a surface wind velocity not exceeding 254.0 mm/second 50 fpm while operating at full load.

2.3.3.3 Watertube, Waterwall Type

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NOTE: On watertube type boilers that will be used intermittently, welded wall construction is recommended to minimize corrosion. In other applications or with fuels containing not more than 0.5 percent sulfur, a casing type enclosure is suitable.

****

Boiler walls shall be [steel-encased wall construction with fabrication details as recommended by the boiler manufacturer. Boiler wall and boiler roof lining shall consist of a continuous screen of closely spaced finned, tangent, or intermittent watertubes. Steel-encased walls shall have casing constructed of not thinner than 3.416 mm 10 gauge black steel sheets, either bolted or welded. Casing shall be gas-tight and shall be reinforced with structural steel to provide rigidity and prevent buckling. Provision shall be made for expansion and contraction. [Refractory behind the waterwall tubes shall be high-duty refractory, not less than 63.5 mm 2-1/2 inches thick.] High temperature block and mineral wool blanket insulation shall be provided between the refractory backup and steel casing, or between an inner and outer casing, and shall be of sufficient thickness to limit the maximum casing temperature in the furnace area to [54] [_____] degrees C [130] [_____] degrees F with a surface air velocity of 508.0 mm/second 100 fpm and an ambient air temperature of 27 degrees C 80 degrees F when operating at full capacity. When boilers are provided with double casings, the inner casing shall be constructed of not thinner than 1.897 mm 14 gauge steel sheets. Alloy steel conforming to ASTM A568/A568M shall be used where temperatures over 370 degrees C 700 degrees F occur.] [of welded wall construction. The width of the fins shall be limited to 19 mm 3/4 inch to prevent overheating of the fins under all operating conditions. Designs exceeding 19 mm 3/4 inch may only be used when provided with supporting calculations and subject to the approval of the Contracting Officer. Tubes shall be seamless type. The fin-to-tube weld shall be continuous and on both the front (fireside) and back side of the fin. The fin shall not be less than 6.4 mm 1/4 inch thick. The construction shall form a pressure-tight structure capable of transferring a maximum amount of heat to the tube. All welded joints and openings shall be checked by a pressure test. Any casing leakage shall be repaired and made pressure-tight. The maximum deflection of the reinforced panels shall not exceed 1/360 of the length of the maximum span. The structure tested shall be capable of holding a pressure of 1.5 times the predicted maximum furnace operating pressure.]

****

NOTE: For personnel safety, the design temperature of the casing surface should not exceed 66 degrees C 150 degrees F. Should the designer wish to use a design surface temperature between 54 and 66 degrees C 130 and 150 degrees F, an economic evaluation must be performed. The evaluation must determine if the additional capital costs for insulation outweigh the cost savings due to reduced boiler radiation losses.

****

2.3.3.3.1 Boiler Roof

Boiler roof shall have a casing constructed of not thinner than 3.416 mm 10 gauge black steel sheet. Refractory lining shall consist of 63.5 mm 2-1/2 inches, minimum, of high-duty refractory backup behind the roof tubes and sufficient thickness of high temperature block insulation or mineral wool blanket to limit the maximum casing temperature in the furnace area to [54] [_____] degrees C [130] [_____] degrees F with a surface air velocity of 508.0 mm/second 100 fpm and an ambient air-temperature of 27 degrees C 80 degrees F when operating at full capacity. Exposed portions of the boiler drums shall be insulated with 75 mm 3 inches of suitable mineral wool blanket or block insulation. Manholes and other inspection and access openings, identification plates, and stamps shall have insulation finished neatly against a metal ring provided for this purpose.

2.3.3.3.2 Bridge Walls

Bridge walls exposed on all sides to radiant heat and to the products of combustion shall be constructed of super-duty refractory not less than 450 mm 18 inches thick, conforming to the boiler manufacturer's requirements; walls having only the front side exposed to radiant heat and to the products of combustion shall have front facing and cap constructed of 225 mm 9 inches of super-duty refractory and a back facing of not less than 225 mm 9 inches of low-duty firebrick. Base of the wall shall be common brick.

2.3.3.3.3 Settling Chamber

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

2.3.3.3.4 Expansion Joints

Expansion joints shall be provided where indicated and else-where as required to permit all brickwork to expand freely without interference with the boiler. Joints shall be of adequate width, tightly sealed against leakage, and free from mortar, with the outer 100 mm 4 inches sealed with resilient mineral wool suitable for 930 to 1095 degrees C 1,700 to 2,000 degrees F. In addition, to allow for expansion of the inner face, a series of 3.2 mm 1/8 inch wide vertical openings spaced 1.8 m 6 feet apart shall be provided on the furnace side of the wall. Proper provision shall be made for expansion and contraction between boiler foundation and floor.

2.3.3.3.5 Firebrick

Firebrick shall be laid up in air-setting mortar. Each brick shall be dipped in mortar, rubbed, shoved into its final place, and then tapped with a wooden mallet until it touches the adjacent bricks. Mortar thick enough to lay with a trowel will not be permitted. Maximum mortar joint thickness shall not exceed 3.2 mm 1/8 inch and average joint thickness shall not exceed 1.6 mm 1/16 inch.

2.3.3.3.6 Plastic Refractory

Install plastic refractory in accordance with the manufacturer's

recommendations and by workmen skilled in its application.

2.3.3.4 Watertube, Waterwall (Packaged Type) Unit

Boiler setting, refractory, insulation, and casing shall be in accordance with ASME BPVC SEC I.

2.3.4 Boiler Fittings and Appurtenances

Boiler fittings and appurtenances suitable for a steam working pressure of [_____] Pa psig and [_____] degrees C degrees F shall be installed with each boiler in accordance with ASME BPVC SEC I.

2.3.4.1 Water column

Water column with straight-through type drain valve shall be provided. Water column shall be complete with gauge glass, high- and low-water alarm, and three quick-closing gauge valves and try cocks fitted with the necessary chains and handles for operation from the boiler room floor. [Water column lighting shall be provided for ease of reading at all times.]

2.3.4.2 Water Gauge

Water gauge drain valve of the straight-through type shall be provided.

2.3.4.3 Low Water Cutoff

Low water cutoff with alarm located on instrument panel shall include either a float-actuated switch as a means of making electrical contact or an electrically-actuated probe type low water cutoff. The float chamber shall be provided with a blowdown connection. The cutoff shall cause a safety shutdown and sound an alarm when the boiler water level drops below a safe minimum level. A safety shutdown due to low water cutoff shall require a manual reset before operation can be resumed and shall prevent recycling of the [burner] [stoker].

2.3.4.4 Bypass Button

A spring-loaded shunt bypass button shall be provided to prevent nuisance shutdowns during sightglass blowdown.

2.3.4.5 Steam Gauge

Steam gauge shall be provided for each boiler in a visible location on the boiler.

2.3.4.6 Feed and Check Valves

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

2.3.4.7 Continuous Blowdown Valve

****

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

****

Continuous blowdown valve shall be manual proportioning type fabricated of corrosion-resistant steel. The valve shall be equipped with a micrometer dial and pointer to indicate the proportional setting.

2.3.4.8 Safety Valves

Safety valves of proper size and of the required number and construction and set pressures shall be in accordance with of the ASME BPVC SEC I and shall be installed so that the exhaust steam will discharge through pipes extending through the roof. Each exhaust riser shall have a drip-pan elbow to prevent the accumulation of water on the valve. A suitable slip joint shall be provided between the drip-pan elbow and the riser.

2.3.4.9 Blowoff Valves

Blowoff valves in tandem shall be provided at each point of blowdown as recommended by the boiler manufacturer. Piping shall be extra-heavy weight, minimum, steel pipe conforming to ASTM A106/A106M Grade B. Blowoff valves shall be the balanced seatless type unless otherwise approved.

2.3.4.10 Steam Nonreturn Valve

Steam nonreturn valve of size and pressure rating shown shall be installed in the steam supply line from each boiler. Valves shall be arranged to close automatically when there is a pressure differential of 34.5 kPa 5 psi between the boilers and steam headers and shall also be arranged to operate as stop valves. Valves shall be set with the stem up, either inclined or vertical, and shall be of the rising stem type. Valves shall be of the angle or straight-way type and shall operate without chattering, hammering, or sticking. Valves shall be cast steel.

2.3.4.11 Feedwater Regulator

Feedwater regulator, sized for the application, shall be connected complete with all necessary piping and accessories for automatic operation. Valved bypass shall be provided around control valve. [Units shall be provided with device to lock regulator in existing position in case of power failure.] [Units shall be provided with manual/automatic selector panel located on instrument panel.] Feedwater control element shall be provided with a drain valve. The feedwater line shall be fitted with a thermometer well.

2.3.4.12 Soot Blowers

****

NOTE: Manually operated rotary soot blowers are normally supplied on boilers up to 6 Megawatts 20 million Btuh. Delete the inappropriate type of soot blower.

****

Soot blowers shall be furnished as required to effectively clean all tube surfaces within the boiler. Steam blowing pressure shall be adjustable. Elements within the boiler shall be constructed of heat-resisting alloys suitable for the flue gas temperature encountered and shall be removable without disturbing the boiler tubes. Soot blowers shall be furnished complete with necessary auxiliaries and shall be connected in accordance

with the manufacturer's recommendations. Soot blowers shall be [permanently-mounted, rotary type manually-operated by a single chain. Valve shall be quick-opening, positive-closing type located in the blower head, external to the boiler, with the working parts protected from the furnace gases, and valve shall be operated by the same chain that rotates the element. Chains shall be continuous extending to within easy reach of the operating floors. Blowers shall be furnished complete with necessary auxiliaries and shall be connected in accordance with the manufacturer's recommendations.] [electrically-operated rotary or retractable type, except that soot blowers exposed to flue gas temperatures over 815 degrees C 1,500 degrees F shall be retractable type only. Rotary type soot blowers shall be provided with a quick-opening, positive closing type valve located in the blower head, external to the boiler, with the working parts protected from the furnace gases, and valve shall be operated by the same motor that rotates the element. Electrically-operated retractable type soot blowers shall have either single motor-driven, totally-enclosed drive carriage with dual rack-and-pinion drives or dual-motor electric drive enclosed in a protective steel housing. Electrically-operated soot blowers shall include starters and pushbutton stations.]

2.4 STOKER EQUIPMENT

The boiler manufacturer shall certify that the stoker selected will be satisfactory for the boiler design. Stokers shall be capable of efficiently burning coal with fuel sizing conforming to ABMA Boiler 203, approximately [_____] mm inches in size with an approximate moisture content of [_____] percent and having the following analyses:

Proximate Analysis	Percent, Dry
Moisture	[_____]
Volatile Matter	[_____]
Fixed Carbon	[_____]
Ash	[_____]
Ultimate Analysis	Percent, Dry
Carbon	[_____]
Hydrogen	[_____]
Nitrogen (Calc)	[_____]
Sulfer	[_____]
Chlorine	[_____]
Ash	[_____]
Oxygen (Diff)	[_____]

Btu/lb as received	[_____]
Btu/lb - dry	[_____]
Grindability	[_____]
Raw Fuel Size	[_____]
Ash Analysis	Percent
SiO(2)	[_____]
Al(2)O(3)	[_____]
TiO(2)	[_____]
Fe(2)O(3)	[_____]
CaO	[_____]
MgO	[_____]
Na(2)O	[_____]
K(2)O	[_____]
SO(3)	[_____]
Ash Fusion Temperatures	Degrees C F
Initial deformation temperature	[_____]
Softening temperature	[_____]
Fluid temperature	[_____]

2.4.1 Spreader Stokers

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NOTE: Any paragraphs describing stoker equipment not necessary for the system specified will be deleted. Stokers and stoking equipment selected will be based on the following:

Boilers having output capacities of 3.5 Megawatts 12,000,000 Btuh or more will be equipped with mechanically-driven grates operating continuously or intermittently. Dump grates will not be permitted in boilers in this size range. Spreader stokers will be specified for watertube boilers using bituminous coal with ash content on a dry basis in excess of 8 percent or ash fusion temperature lower than 1204 degrees C 2200 degrees F.

Underfeed or pulsating grate stokers may be

specified for firebox packaged boilers when bituminous coal of any composition is used. Underfeed stokers will be the screw-feed type for boilers with capacity of less than 1635 kg (3600 pounds) of steam per hour, and the ram type for larger boilers. Pulsating grate units will be water-cooled and complete with automatic coal feed and continuous ash removal. Conveyor stokers may be specified for watertube boilers if suitable for the type of coal available. Chain or traveling grate may be specified by deletion of the inapplicable type of grate, or the choice between the two types may be left to the Contractor by including both types in the description. If steam drives are specified, plant must have an auxiliary boiler or an alternate source of steam for startup. The following is a general guide in determining which type of grates to investigate:

Size Steam rate of boiler kg/hr lb/hr	Type of Grate and Stoker
1,135 - 9,070 2,500 - 20,000	Single retort, stationary grate, underfeed stoker
9,070 - 13,600 20,000 - 30,000	Single retort, moving grate, underfeed stoker
2,270 - 34,020 5,000 - 75,000	Reciprocating grate, front continuous ash discharge stoker
2,270 - 45,360 5,000 - 100,000	Vibrating conveyor grate, front continuous ash discharge stoker

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Spreader stokers shall be the overfeed self-feeding type suitable for burning a portion of the coal in suspension, but sized assuming 100 percent combustion on the grate. [Coal shall be evenly distributed across the full width of the grate by not less than [_____] feeder units. Unit shall be designed for operation of any feeder independently of the others, or it shall be possible to operate all feeders simultaneously.] Feeders shall be capable of handling and uniformly distributing coal over the grate area. Feeders shall be the mechanical-rotating type, shall have no moving parts within the combustion chamber, and where moving parts are exposed to excessive heat, such parts shall have all bearings protected by suitable water jackets. Grease or oil lubrication shall be provided for all bearings. Stoker shall be designed for readily adjustable feed distribution of coal on the grates.

2.4.1.1 Spreader Stoker Grates

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NOTE: Steam driven boiler auxiliaries will not be used unless the exhaust steam can be utilized completely. Reference to steam drives will be deleted if inapplicable for the equipment specified.

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Grates for spreader stoker firing shall be of the high air-resistant type

especially designed and arranged for powered mechanical or compressed air actuated dumping in sections. Openings shall provide proper distribution of air under the fuel bed. [Grates shall be in sections to match the feeders with provisions for shutting off the forced draft to each section so that any section of the grate can be cleaned while the others remain in service.] Grates shall be heavy-duty, heat-resisting cast-iron. Mechanical dumping shall be with [steam-] [air-] [water-]actuated power cylinders connected to the grates, and grates shall be furnished complete with cylinders, linkages, valves, and piping as required. Each section shall dump independently of other sections. Necessary over-fire air jets complete with fans, ducts, and air control valves shall be provided as required for proper turbulence and combustion. Grate drives shall be independent of feeder drives to provide independent speed variation of feeders and grates.

2.4.1.2 Traveling Grates

Traveling grates shall be high air-resistant type especially designed for spreader stoker firing and for continuous ash discharge. Openings shall provide proper distribution of air under the fuel bed. Grates shall be heavy-duty, heat-resisting cast-iron, and individual sections shall be replaceable without taking the grate out of service. Air seals around grate shall hold air leakage to a minimum. Moving grates shall be furnished complete with supporting steel, shafts, sprockets, chain, gears, skid bars, and bearings as required. The front end of the grates where the ash is discharged shall be enclosed with a dust-tight enclosure made of heavy cast-iron plates not less than 15.9 mm 5/8 inch thick and properly protected with firebrick where exposed to the furnace, or shall be of refractory-lined steel plate. The vertical fronts of the enclosure shall be fitted with refractory-lined inspection and access doors, one for each feeder. The roof of the enclosure shall be sealed with refractory to protect the metal parts from the furnace temperature. The underside of the grates shall be enclosed to form a chamber. Hopper for receiving the ashes shall be constructed as indicated or as recommended by the manufacturer. Over-fire air jets shall be provided as required for proper turbulence and combustion.

2.4.1.3 Vibrating Grate

Vibrating grate of high air-resistant type shall be especially designed for spreader stoker firing and for continuous ash discharge. Grates shall be either air- or water-cooled with openings to provide proper distribution of air under the fuel bed. Grates shall be heavy-duty, heat-resisting cast iron and individual sections shall be replaceable. A manual adjustment shall be provided to regulate the ash bed thickness and ashes shall be automatically discharged to the ash pit. The front of the grates where the ash is discharged shall be enclosed with a dust-tight enclosure of heavy cast-iron plates not less than 15.9 mm 5/8 inch thick and properly protected with firebrick where exposed to the furnace, or shall be of refractory-lined steel plate. The vertical fronts of this enclosure shall be fitted with refractory-lined inspection and access doors, one to each feeder. Roof of this enclosure shall be sealed with refractory for protecting the metal parts from the furnace temperature. The underside of the grates shall be enclosed to form a chamber with a hopper for receiving the ashes. Over-fire air jets shall be provided for turbulence and combustion.

2.4.1.4 Stoker Controls

Stoker controls that accurately regulate the coal feed rate shall be of the type required for connection to the combustion control system. Manual setting of the coal feed rate with variation of stoker feed, as required to maintain any desired capacity between 50 and 110 percent of boiler capacity, shall be possible without disconnecting linkage. Separate feeder and grate drives shall be provided. Grate shall be driven through a variable speed transmission with devices for changing speed interlocked with fuel feed regulation. Manual adjustment of grate speed shall only be for allowing synchronization with fuel feed. All gears and chains of the variable speed transmission and gear reduction units, as required, shall run in a bath of oil and be enclosed in a dust-tight and oil-tight case. Front and rear shafts of the grates shall be fitted with a forced lubrication system with fittings located outside the setting. All bearings shall be of the antifriction type with hardened inner and outer races fitted with dust seals and easily accessible forced lubrication fittings. Stoker [and grate] shall be provided with safety release devices to protect the mechanism from foreign materials or obstructions. Stoker shall be driven by [electric motor] [steam turbine]. [Electric motor shall be totally enclosed fan-cooled for installation in Class II, Division 1, Group F hazardous location in accordance with NFPA 70. Motor starter shall be magnetic [across-the-line] [reduced voltage start] type with [general-purpose] [dust-tight] [explosion-proof] enclosure.] [Steam turbines utilized for stoker drives shall conform to NEMA SM 23.]

2.4.1.5 Hoppers

Hoppers shall be constructed of steel plates not less than 6.4 mm 1/4 inch thick and shall have a capacity of not less than [_____] kg pounds per feeder. Hoppers shall be provided with clean-out doors in the front of each feeder. Coal feed to the hoppers shall be fitted with concave type transitions to ensure the proper distribution of coal and coal fines across the width of the hoppers. Stoker front plate shall form the front of the boiler for the full width of the boiler and from the firing floor to some point above the stoker where it shall connect to the boiler structural framing. Front shall be cast-iron or steel plate refractory lined with [auxiliary firing doors and] clean-out doors of refractory lined cast-iron. Structural framing as required shall support the stoker and its components from the boiler foundation or boiler room floor. The area under the grates shall be divided into not less than four airtight zones for supply of forced draft having zone control dampers with external indicating operating and locking devices. All pressure parts for water-cooled grates including watertubes, headers, and valves furnished by the stoker manufacturer shall be for boiler pressure specified and shall be constructed in conformance with ASME BPVC SEC I.

2.4.1.6 Over-Fire Turbulence and Cinder and Dust Reinjection System

Spreader stokers shall be provided with over-fire turbulence and cinder-and-dust reinjection systems. Either air or steam may be used as the transport medium. Air systems shall be provided with operating air by a single, low volume, high-pressure fan, driven by a splashproof electric motor. The reinjection system ejectors shall be properly designed, located, and sized for maximum fly ash pickup from all points. Nozzles for each system shall be equipped with manometer connections and heavy-duty adjustable dampers fitted with locking devices and position indicators. Nozzles shall provide maximum combustion efficiency and furnace turbulence. A manometer connection and a permanent manometer shall

be provided immediately downstream from the main reinjection air supply damper. A portable manometer shall be provided.

2.4.2 Underfeed Stokers

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NOTE: Any paragraphs describing stoker equipment not necessary for the system specified will be deleted.
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2.4.2.1 Single Retort, Heavy-Duty Ram-Type Stokers

Single retort, heavy-duty ram-type stokers shall be equipped with stationary or moving grates and side dump plates, and shall be provided with [steam] [electric motor] drive and all necessary auxiliary equipment. Dumping power cylinders shall be compressed air actuated. Coal shall be fed from the hopper into the retort by means of a ram and shall be evenly distributed along the full length of the retort with auxiliary pusher blocks on a pusher rod located at the bottom of the retort and actuated by the coal ram. Dampers shall be provided between ash pits and main air chamber under stoker to permit control of air distribution to the grate surface. Dampers shall be arranged for operation from the front plate of the boiler. Air distribution shall be such that the air pressure is greatest where the fuel bed is the thickest. Air quantity shall vary in direct proportion with coal feed rate and shall be controlled automatically.

2.4.2.1.1 Grate Surface

Grate surface shall include the underfeed retort area, air admitting tuyeres, side combustion grates, and the side dumping plates. Retorts shall be sectional construction of large capacity and proper shape to distribute coal uniformly over the entire grate surface with a minimum of moving parts within the furnace. Stokers having total grate width of more than 2.1 m 7 feet shall have movable grates providing positive lateral feeding of the coal from the retort toward the dump plates. Retort and grate sections shall be constructed of heavy-duty, heat-resisting cast iron, shall be cored for proper air distribution, and shall be designed for easy replacement of individual sections. Ash dump plates shall be provided with necessary levers and linkage for hand operation from the front of the boiler.

2.4.2.1.2 Ram Feed

Ram feed shall be mechanical [steam] [pneumatic or hydraulic] [driven by an electric motor connected through an efficient gear reduction unit, crankshaft, and connecting rod]. [Motors shall be totally enclosed fan-cooled type [for installation in a Class II, Division 1, Group F hazardous location in accordance with NFPA 70]]. [Motor starter shall be magnetic [across-the-line] [reduced voltage start] type with [general-purpose] [dust-tight] [explosion-proof] enclosure.] Stoker controls shall be for connection to the combustion control system to accurately regulate the coal feed rate. Manual setting of the coal feed rate shall be possible without disconnecting linkage, with variation of stoker feed as required to maintain any desired capacity between 25 and 110 percent of boiler capacity in 10 or more equal increments. Regulation of the coal feed rate shall be by varying the time increments between strokes of the ram. A throw-out release shall protect the coal feeding

mechanism from injury in case foreign materials obstruct normal operation.

2.4.2.1.3 Hoppers

Hoppers shall be constructed of steel plates not less than 6.4 mm 1/4 inch thick and shall have a capacity of not less than [_____] kg pounds. Hoppers shall be provided with clean-out doors. Stoker front plate shall form the front of the boiler for the full width of the boiler and extend from the firing floor to some point above the stoker where it shall connect to the boiler structural framing. Front shall be cast-iron or steel plate, refractory lined with [auxiliary firing doors and] clean-out doors of refractory lined cast-iron. Structural framing, as required, shall support the stoker and its components from the boiler foundation or boiler room floor. Water spray pipes and nozzles shall be provided for quenching the ashes in the ash pit.

2.4.2.2 Single Retort Screw Type Stokers

Single retort, heavy-duty, screw feed stokers shall be equipped with rectangular firepot, side dump grates, forced-draft fan, electric-motor drive, and all necessary auxiliary equipment. Coal shall be fed from the hopper into the retort with a spiral worm conveyor designed to feed a constant amount of coal and to prevent coal from packing in the worm. [Dampers shall be provided between ash pits and main air chamber under stoker to permit control of air distribution to the grate surface. Dampers shall be arranged to be operated manually from the front plate of the boiler.] The stoker shall be provided with an integral, forced-draft fan driven by the stoker motor. Air quantity shall vary in direct proportion with the coal feed rate and shall be controlled automatically. Retorts and grates shall be constructed of heavy-duty, heat-resisting cast-iron, shall be cored for proper air distribution, and shall be designed for easy replacement of individual sections. Retorts shall be of proper size and shape to distribute coal uniformly over the entire grate surface. Stationary grates shall be provided on all sides of the retort as required to suit the firebox. [Ash dump grates shall be provided on each side of the retort complete with necessary levers and linkages for hand operation from the front of the boiler.] Electric motor shall be belt-connected to an efficient gear reduction unit which shall drive the feed screw and forced-draft fan. Gear reduction unit shall be immersed in oil in a dustproof housing. Stoker controls shall be suitable for connection to the combustion control system to accurately regulate the coal feed rate. Feed rate control shall allow manual setting for not less than three speeds and neutral, in equal increments, with speed changes possible while stoker is running. A suitable release shall protect the coal feeding mechanism from injury in case foreign materials obstruct normal operation. Motors shall be totally enclosed fan-cooled type [for installation in a Class II, Division 1, Group F hazardous location in accordance with NFPA 70]. Motor starter shall be [manual] [[magnetic] [across-the-line] [reduced voltage start] type with [general-purpose] [dust-tight] [explosion-proof] enclosure.] Hoppers shall be constructed of 6.4 mm 1/4 inch steel sheet, minimum, shall be reinforced, and shall have a capacity of not less than [_____] kg pounds. Hoppers shall be provided with suitable cleanout. Feed screw shall be removable and conveyor compartment shall have cleanout. Stoker shall rest on boiler room floor.

2.4.3 Conveyor Stokers

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NOTE: Any paragraphs describing stoker equipment

not necessary for the system specified will be deleted.
****

Conveyor stokers shall be of the grate level feed, forced-draft [chain grate] [traveling grate] type with hoppers, feed gate, drive shaft, sprocket wheels, grate, [electric motor] [steam] drive, and all necessary auxiliary equipment. Coal shall be fed automatically at a constant rate from the hopper onto the moving grate and shall be evenly distributed across the full width of the grate. The stoker frame shall be provided with not less than four air-tight zones for supply of forced draft and shall have suitable zone control dampers with external indicating, operating, and locking devices.

2.4.3.1 Grates

Grates shall have individual sections constructed of heavy-duty, heat-resisting cast-iron, shall be fitted or cored for proper air distribution, and shall be designed for easy replacement of individual sections. [Chain grates shall have staggered links connected by pins to form a continuous flat chain the full width of the furnace.] [Traveling grates shall have grate blocks mounted on carrier bars which, in turn, shall be fastened to two or more drive chains to form a continuous flat grate surface the full width of the furnace.] Continuous grates shall be supported at the ends by suitable sprockets and at intermediate points on suitable tracks or skids.

2.4.3.2 Grate Operation

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NOTE: Steam driven boiler auxiliaries will not be used unless the exhaust steam can be utilized completely. Reference to steam drives will be deleted if inapplicable for the equipment specified.
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Conveyor grate shall be driven by [electric motor connected through a suitable speed reduction unit] [steam] [hydraulically operated variable speed drive]. Gears and chains required for the drive shall be enclosed in a dustproof and oil-tight housing. Main shafts for the grates shall have a forced system of lubrication with fittings located outside the casing or have self lubricating bearings. If the forced lubrication system is supplied, bearings shall be fitted with dust seals and easily accessible forced lubrication fittings. Stoker controls shall be suitable for connection to the combustion control system to accurately regulate the coal feed rate. Manual setting of the coal feed rate by varying stoker feed, as required to maintain any desired capacity between 25 to 125 percent of boiler capacity, shall be possible without disconnecting linkage. Feed rate shall be changed by varying the speed of the grate. Air volume shall automatically vary in direct proportion with the feed rate. Possible feed rate shall vary in not less than 10 equal increments. [Electric motor shall be totally enclosed fan-cooled type [for installation in a Class II, Division 1, Group F hazardous location in accordance with NFPA 70.]] [Motor starter shall be [manual] [magnetic] [across-the-line] [reduced voltage start] type with [general-purpose] [dust-tight] [explosion-proof] enclosure.]

2.4.3.3 Hoppers

Hoppers shall be constructed of steel plates not less than 6.4 mm 1/4 inch thick, shall have a capacity of not less than [_____] kg pounds, and shall be provided with suitable cleanout doors. Coal feed to the hoppers shall be fitted with concave type transitions to ensure the proper distribution of coal and coal fines across the width of the hoppers. Stoker frame shall be constructed of cast-iron, cast steel, or forgings, and all parts of the stoker, except the grates, shall be properly cooled or otherwise protected from the furnace heat to prevent damage by warping or undue expansion. Furnace arrangement and shape shall be as recommended by the stoker manufacturer to ensure proper combustion of the fuel. Stoker front plate shall form the front of the boiler for the full width of the boiler and extend from the firing floor to some point above the stoker where it shall connect to the boiler structural framing. Front shall be cast-iron or steel plate, refractory lined with cleanout doors of refractory lined cast iron. Structural framing, as required, shall support the stoker and its components from the boiler foundation or boiler room floor. At the end of the grate, the ash shall be discharged into a bunker or pit as indicated. The bunker shall have a dust-tight enclosure made of steel plates not less than 15.9 mm 5/8 inch thick, properly protected with firebrick where exposed to the furnace; shall be fitted with cast-iron, refractory lined inspection and access doors; and shall have provisions for ash removal.

2.4.4 Vibrating Grate Stokers

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NOTE: Any paragraphs describing stoker equipment not necessary for the system specified will be deleted.

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Vibrating grate stokers shall be the grate level feed, forced-draft type with the vibrating action of the grate used to feed the coal from the hopper through the furnace and discharge the ashes into the ash pit. Stokers shall be complete with hopper, feed gate, grate, drive mechanism, and all necessary auxiliary equipment. Coal shall be automatically fed from the hopper onto the grate and shall be evenly distributed across the full width of the grate. A manual adjustment shall be provided to regulate the fuel bed thickness. Ashes shall be automatically and continuously discharged to the ash pit. The area under the grates shall be divided into not less than four airtight zones for forced draft supply and shall have suitable zone control dampers with external indicating, operating, and locking devices.

2.4.4.1 Grates

Grates shall be either air cooled or water cooled with grate bars in intimate contact with the watertubes. Grates shall have individually replaceable sections of iron or steel suitable for the temperatures encountered. Pressure parts, including watertubes, headers, and valves shall be suitable for boiler pressure specified and shall be constructed in accordance with ASME BPVC SEC I. Grate sections shall be properly designed for even air distribution over the entire grate area.

2.4.4.2 Stoker Controls

Stoker controls shall be designed for connection to the combustion control

system to accurately regulate the coal feed rate and shall be arranged for manual operation independent of the combustion control system. Variation of coal feed rate shall be accomplished by changing the length of time of vibrations. Vibration generator shall be belt connected or gear connected to the electric motor. Unit shall be free of any vibration that may damage other parts of the boiler or the building structure. Bearings requiring lubrication shall be provided with easily accessible lubrication fittings. Combustion air volume shall automatically vary in direct proportion with the coal feed rate. Stoker shall be driven by [electric motor] [steam turbine]. [Motor shall be high-starting torque [totally enclosed, nonventilated] [totally enclosed, fan-cooled] [totally enclosed, fan-cooled suitable for installation in a Class II, Division 1, Group F hazardous location in accordance with the NFPA 70].] [Motor starter shall be magnetic, reversing, [across-the-line] [reduced voltage start] type with [general-purpose] [dust-tight] [explosion-proof] enclosure.]

2.4.4.3 Hoppers

Hoppers shall be constructed of steel plates not less than 6.4 mm 1/4 inch thick, shall have a capacity not less than [_____] kg pounds, and shall be provided with a suitable method of cleanout. Furnace arches of a design suitable for the intended use and a type that will ensure proper combustion of the fuel shall be provided. Lower furnace sidewall headers in a waterwall boiler shall be inclined to accommodate the inclined grate arrangement. Stoker front shall form the front of the boiler for the full width of the boiler and shall extend from the firing floor to some point above the stoker where it shall connect to the boiler structural framing. Front shall be cast-iron or steel plate refractory lined with cleanout and access doors of refractory lined cast-iron. Structural framing, as required, shall support the stoker and its components from the boiler foundation or boiler room floor. At the end of the grate the ash shall be discharged into a bunker or pit as indicated. The bunker shall have a dust-tight enclosure made of steel plates not less than 15.9 mm 5/8 inch thick properly protected with firebrick where exposed to the furnace and shall be fitted with cast-iron, refractory lined inspection and access doors, and provisions for ash removal as indicated.

2.5 PULVERIZED COAL BOILERS

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NOTE: Pulverized coal boilers require special consideration since they are usually designed to operate on one specific type of coal and usually are utilized for large units where a steady minimum load of 68,040 to 90,720 kg per hour 150,000 to 200,000 pounds per hour is assured.

Small horizontal type units down to 36,290 kg per hour 80,000 pounds per hour of steam are available, but horizontal units also will range up to 113,400 kg per hour 250,000 pounds per hour of steam. Larger units are usually the vertical type.

The type of pulverizer will be determined from the coal analysis and the boiler manufacturer's requirements. The pulverizer selected also affects the control system requirements. The furnace ash disposal system components will depend on the ash characteristics and EPA requirements. Volumetric

heat release should be 745.2 Megajoules/cubic meter 20,000 Btu/per cubic foot of furnace volume. Coal is crushed in a central plant and stored in bunkers. Each boiler has two pulverizers, fed by a drag type coal feeder, and in turn feed the burners. This system requires room within the plant to accommodate the coal pulverizers. Fineness of pulverized coal may vary with different designs, and fine pulverized coal will significantly affect the selection of ash handling and pollution control equipment and will require special consideration for erosion control on induced-draft fan. Where pulverized coal boilers are specified, reference to stoker fired boilers will be deleted.
****

Where indicated, pulverized coal boilers shall be provided. Boiler and boiler accessories shall be specifically designed to operate on the fuel specified. Boilers shall be complete with coal feeders, crushers, dryers, burners, ignition system, air preheater, economizer, soot blowers, controls, and complete furnace ash handling facilities. Fly ash collection and pollution control equipment is specified in Section 44 10 00 AIR POLLUTION CONTROL. Boilers shall be [horizontal] [vertical] type and shall be [top] [bottom] supported. Ash hoppers shall be dry, refractory-lined type divided into compartments, each of which shall have a hydraulically-operated clean-out door. The hopper shall be supported from the boiler and a dry seal shall provide gastight connection. Forced draft and induced draft fans shall be furnished with the boiler.

2.5.1 Coal Pulverizers

Each boiler shall be provided with a minimum of two pulverizers arranged to allow operation of boiler at reduced capacity when one pulverizer is taken out of service either for maintenance or for operation of low loads. Coal pulverizer shall be provided complete with all required accessories such as rotary drum feeder unit, air preheater, fans for drying coal by either the primary air or suction system, coal classifier distributor unit, and shut off coal valves to allow isolation of individual burners. Drum feeder unit shall have a tramp metal rejection device incorporated in the unit.

2.5.2 Burners

Pulverized coal burners shall be specifically designed for the boiler provided. Burner shall include an ignition system designed for ignition of pulverized coal.

2.5.3 Furnace Ash System

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NOTE: Detail of piping supported in trenches will appear on the drawings.
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The boiler shall be the dry bottom type, discharging ash to the hopper compartments. Pulverized coal boiler ash shall be handled hydraulically rather than pneumatically. Facilities for pulverized coal boiler ash handling shall be as indicated. Fly ash shall not be mixed with furnace ash but economizer ash can be combined with furnace ash as indicated.

Dual ash dewatering bins to allow recirculation of ash conveying water shall be as indicated. Each bin shall be provided with automatic controls and hydraulically operated gate for ash unloading to trucks or railroad cars. Hopper shall be maintained in flooded condition and hydraulically operated sluice gates shall allow for periodic removal of ash. Each ash hopper compartment shall be fitted with double-roll, electric motor driven clinker grinders fitted with manganese steel crusher rolls and teeth. Discharge from the grinders shall be to an adaptor or to a sump for feed to the centrifugal pump. Centrifugal pump for each hopper compartment shall be provided and shall incorporate special abrasive resistant metals and special seals for abrasive slurry handling. Drives shall be totally enclosed electric motors as indicated. Ash slurry conveying pipelines shall be made of abrasive resistant alloy metal with a Brinell hardness number of approximately 280. Wall thickness shall be not less than 13 mm 1/2 inch and pipe lengths shall not exceed 5.5 m 18 feet. Fittings shall be of the tangent end type. Fittings shall have a Brinell hardness number of approximately 400 and shall have removable wearbacks, where applicable, or shall be of the integral wearback type. Loading facilities for ash removal of dewatering bins shall be as indicated.

2.5.4 Pulverizer Rejects

Pulverizer rejects such as tramp iron or pyrites shall be collected in hoppers adjacent to each mill discharge spout. High-level hopper indicators shall be provided to initiate reject removal, in sequence, from each hopper to the central holding bin by properly sized jet pumps. Mill discharge control gates shall be provided and the control system shall be interlocked with the furnace ash removal system to provide a completely automatic disposal system. Discharge of mill rejects into the ash hopper is not acceptable. The central holding bin and loading facilities shall be as indicated.

2.5.5 Control Systems

Pulverized coal plant control systems shall be in accordance with NFPA 85 and shall be interlocked to provide for a completely automatic boiler operation. Automatic controls for coal feed, pulverizer operation, combustion, and ash disposal systems shall be coordinated.

2.5.5.1 Coal Master Control System

Coal master control system shall regulate the total coal feed from the coal [bunkers] [silos] to the pulverizers in response to changing demand. A parallel metering combustion control system that limits the firing rate to the actual total air flow available shall be provided. The cross limiting of air and fuel shall be arranged so the air leads the fuel on load increase and trails the fuel on a load decrease. A gain changer shall be provided to compensate the fuel system for the number of pulverizers in service. Depending on the requirements of the pulverizer, the coal master control system shall be actuated by the coal feeder speed or by the coal/air mixture. The total fuel controller shall be a standard, proportional plus integral controller with a derivative or rate term on the master demand only. Change in master demand shall be multiplied by the derivative circuit to assist in overfiring on load increase and underfiring on a load decrease. Provision shall be made for taking any one of the pulverizers for each boiler out of service with firing continuing at reduced rates for extended periods during maintenance or during low demand intervals. Alarms and interlocks of the fuel master control shall be as required by the boiler but shall include, as a

minimum, a unit trip to run the fuel master to zero and alarm contacts for "fuel master at maximum," "fuel master at minimum," "fuel greater than air," and "air demand limiting fuel."

2.5.5.2 Primary Air

Primary air fan or suction air fan control for each system shall be provided with all required damper operating and sensing control devices. Primary air system fans shall exhaust into a duct common with individual pulverizer primary air flow dampers in order to control the flow required by each pulverizer. Common duct pressure shall be maintained at a given set point by modulating fan inlet dampers. Gain compensation shall be provided to maintain system response with a different number of fans in operation. Biasing between fans shall be provided.

2.5.5.3 Air Temperature Control

Pulverizer coal air temperature control, for each pulverizer coal air exit, shall assume the maximum safe mixture temperature required to increase the firing efficiency at the furnace and to remove additional residual moisture that may be present in the coal. Tempering air inlet with controls shall be provided to prevent combustion in the pulverizer.

2.5.5.4 Flame Safety System

A burner control/flame safety system shall be provided with the boiler. The system shall meet the requirements specified in NFPA 85 as a minimum. An interface shall be provided between the analog control system and the flame safety system or burner control system. As a minimum, coal feeders and pulverizer air dampers shall be positioned to respond to "unit tripped" and "pulverizer tripped" signals. Burner controls shall incorporate a pulverized coal ignition system. The burner control system shall incorporate boiler shutdown as well as normal monitoring of startup sequencing and normal operation. Each burner shall have a scanner for the lighting system as well as a scanner for the main flame.

2.6 FLUIDIZED BED COMBUSTION BOILERS

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NOTE: The designer will perform an economic analysis to compare the installation and operating costs of a fluidized bed combustion boiler against the use of a conventional boiler and its associated air pollution control equipment.

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Where indicated, fluidized bed combustion boilers shall be provided. The Contractor may provide either bubbling bed (AFB) or circulating bed (CFB) boilers. Fluidizing velocities shall range from 1.2 to 3.7 m/second 4 to 12 fps for AFB boilers and range from 4.3 to 9.1 m/second 14 to 30 fps for CFB boilers. Each boiler shall be in compliance with sulfur dioxide, nitrogen oxides, particulate, carbon monoxide, and all other emission regulations, as specified. The bed temperature shall be controlled within the appropriate range, normally 815 to 900 degrees C 1500 to 1650 degrees F to enhance sulfur capture, inhibit the formation of nitrogen oxides, enhance combustion efficiency, and limit carbon monoxide formation. In AFBs, generally all the air required for combustion shall be introduced through the nozzles in the distribution plate in order to reduce the potential of forming reducing conditions within the bed that could cause

severe corrosion of in-bed surfaces. The use of over-fire air in applications where it is needed to complete the burnout of carbon monoxide and the combustion of fines in the freeboard shall require the approval of the Contracting Officer who shall be satisfied that reducing conditions will not exist. CFB boilers may introduce as much as 40 to 50 percent of the combustion air as secondary air in one or more stages at various locations above the distribution plate. The boiler and boiler accessories shall be specifically designed to operate with the specified fuel and sorbent. The boilers shall be complete with the required crushers, dryers, coal and sorbent handling systems, burners, ignitors, air preheater, economizer, soot blowers, boiler controls and instrumentation, furnace ash handling system, draft systems, and superheater, where required.

2.6.1 General

The design, materials, and construction of equipment furnished shall conform to the applicable requirements of ASME BPVC SEC I and NFPA 85. Furnish the Manufacturer's Data Report required by ASME BPVC SEC I certified by the Authorized Inspector located in the manufacturer's shop. Full provision shall be made so that each component can expand and contract under the operating cycle of temperatures without damage to itself or to any adjoining component, and without the leakage of any contained fluid outwards, or of air either inwards or outwards. The design of the unit shall accommodate thermal movement without side effects such as tearing, buckling, distortion, or vibration. The design of the unit shall prevent destructive vibration during normal operation. The furnace shall be of the balanced draft type. The ducts and equipment from the forced draft fan, including the fluidized bed plenums, shall be designed for pressures in accordance with NFPA 85. Access and observation doors shall be provided to permit access to compartments and the observation of critical portions of the furnace and fluid bed. Door frames shall be securely anchored. Doors shall have a suitable durable gasket, a device which when closed will force the door to an air-or gas-tight seal, and an interior design which will minimize erosion or deterioration of the inner surface from exposure to the internal conditions at that point. Refractory shall be an integral part of the door. Access doors shall be the manufacturer's standard that approaches in size 450 mm 18 inch wide by 400 mm 16 inch high. All observation ports and lance doors shall be provided with sealing and aspirating air facilities. The convection pass velocity shall not be greater than 15.2 m/second 50 fps. The convection pass velocity shall be based on maximum guaranteed excess air at Maximum Continuous Rating (MCR) plus five percentage points (i.e., if excess air is 20 percent, the convection pass velocity shall be based on 25 percent excess air). In CFB designs where convection surface exists in the high solids circulation passes, a velocity not greater than 4.6 m/second 15 fps is permitted between the tubes, based on 25 percent excess air. The design of the equipment shall be such that the interior surfaces of all water-filled pressure parts and superheater sections shall be capable of being chemically cleaned. Furnish, as required, fill and drain connections. Each header shall be drainable. Provide the secondary air and flue gas system resistance curves.

2.6.2 Furnace and Boiler

The boiler shall be of the water-tube welded-wall type, having in-bed tube surface for AFB offerings with natural and/or forced circulation. Tubes shall be seamless and all connections shall be welded. Tubes of the

electric resistance welding process, where used, shall be identified by the Contractor and shall be ultrasonically tested along their entire length by the Contractor. Provide permanent thermocouples, as required, run to a terminal box outside the boiler casing. As a minimum, these thermocouples shall indicate:

a. Water wall temperature in critical locations (risers, etc.).

b. Heat absorption rates (cordial type t/c).

c. Air and gas temperatures.

d. Water and steam temperatures.

Drums shall be fusion welded throughout and fitted with manholes and hinged covers at both ends. The hydrostatic test temperature shall be carefully monitored, as indicated in paragraph "TESTS," to avoid brittle failure. Boiler drains shall be furnished sufficient in size and number to completely drain the water from the entire unit in not more than 1 hour at 0 kPa psig pressure. The drum shall be equipped with internals for steam separation.

2.6.3 Forced Circulation System

Boiler designs utilizing horizontal in-bed evaporating surfaces shall be provided with a forced circulation system. The number and capacity of the pumps installed shall be such that with one pump out of service, the maximum rating of the boiler can be carried with complete safety. In addition, loss of all pumps, with the unit at MCR, shall allow for a safe and orderly shutdown (without fans) without damage to the boiler. The pumps shall be single stage, centrifugal, driven by constant speed motors. Pumps shall be complete with all necessary accessories, including welded suction and discharge connections, lubrication system, casing drain valves in duplicate, and any necessary auxiliary pumps, heat exchangers, or other equipment. The pumps shall withstand the boiler test pressure and all operating pressures and temperatures without distortion, binding, or other effects. The casings shall withstand the forces and moments imposed upon them by the connecting piping without disturbing the alignment or successful operation of the pumping units. The construction shall be such as to permit inspection of the rotating parts without dismantling the suction and discharge piping. The pumps shall operate satisfactorily at all loads, either by themselves or in parallel with the other pumps furnished. The pump suction valves shall be motor operated. Bypasses with valves shall be furnished around the pump isolating valves to maintain operating temperature in the idle pumps and piping. The discharge valves shall have impactor handwheels and lugs for air motor drive. Orifices, with protecting strainers as required, shall be provided to assure adequate circulation to all parts of the boiler circuits. All materials that may come in contact therewith shall be suitable to withstand acid and caustic boiler cleaning solutions. Connecting lines with stop valves shall be provided between the main distributing header and the economizer inlet header for use as a circulating line to the economizer when the boiler is acid cleaned.

2.6.4 In-Bed Tube Surface (AFB Designs)

In-bed tube surface shall be provided as required to achieve steam generation or superheat temperature as defined in the data sheets. The in-bed tubes shall be completely clear of bed material when the fluid bed

(at the bed weight specified by the manufacturer at boiler MCR) is slumped. Alternatively, the manufacturer shall ensure that the tubes are protected from overheating due to contact with a slumped bed and/or maintenance problems due to moisture in a slumped bed.

2.6.5 Coal and Sorbent Feed Systems

All equipment required to provide a boiler feed system to convey coal and sorbent to the boiler injection inlets shall be furnished. All components of these systems shall be sized to provide flow of fuel and sorbent based on MCR condition in the boiler and the design coal and sorbent specified. The system shall be designed to minimize the segregation or generation of fines.

2.6.5.1 AFB Coal Feed System

Coal feed systems for AFB may be either pneumatic under bed or spreader stoker over-bed. For pneumatic under-bed feed systems, a feed point every 1.7 to 2.3 square meters 18 to 24 square feet shall be provided. The system shall consist of a complete integrated system including weigh belt feeder, lock hoppers, and/or other components necessary for the pneumatic fuel injection system. Rotary type feeders shall not be used as the primary pressure sealing device. The conveying air shall be considered part of the combustion air. Coal feed shall be crushed to approximately 6.4 mm 1/4 inch and shall be capable of being used with fluidizing velocities ranging from 1.2 to 3.7 m/second 4 to 12 fps. For these systems, sorbent may be mixed with the coal in the appropriate proportion and fed with the fuel. However, a separate sorbent feed system is acceptable. Over-bed feed systems shall be designed to provide even distribution over the entire bed. Heavy duty standard production spreader/injector/feeders shall be provided for dispersing the specified fuels into the boiler. The spreader/feeders shall be the chain type or equal, as approved by the Contracting Officer. The feeder portion shall be of the chain type with infinitely adjustable feed rate from 0 to 100 percent of rated capacity. The spreaders shall consist of adjustable rotating paddles on a shaft designed to disperse the specified coals into the boiler at the required locations and to minimize side throw into adjacent bed compartments which may not be in operation. The spreaders shall be capable of rotating at variable rates of speed. The spreader/feeders shall have overfire capability to the extent required by the design for use in compensating for a spreader/feeder out of service. For spreader stoker coal feed systems, sorbent feed shall be by separate systems. These systems shall consist of a method to feed the correct proportion of sorbent over the load range to keep the sulfur oxides emission in compliance. These systems shall feed over-bed or in-bed and may be gravity, pneumatic, or a combination. Under-bed coal feed systems shall be provided with coal dryers unless approved.

2.6.5.2 CFB Coal Feed Systems

For CFB systems, feed systems capable of providing the appropriate coal feed over the load range shall be provided. These systems shall include weigh belt feeders, rotary feeders, screw conveyors or air swept feeders, or gravity-feed metered by weigh belt. Rotary type feeders shall not be used as the primary pressure sealing device. The fluidizing velocity in systems ranges from 4.3 to 9.1 m/second 14 to 30 fps. The design shall permit maintenance of full load with loss of a single feed point. Screw conveyors shall be designed to operate continuously. Sorbent feed for CFB systems shall be capable of providing the required proportion of sorbent

over the load range. These systems shall consist of a sorbent metering device weigh belt feeder and be fed by gravity, pneumatic injection, or air swept feeder. The sorbent shall be fed in-bed, under-bed, or over-bed, and shall be fed separately from the fuel.

2.6.6 Fluidized Bed Combustion Area

Parts subject to severe wear or deterioration shall be replaceable with a minimum of dismantling. The fluid bed combustor shall be designed to insure that no combustion air entering the bed is allowed to bypass contact with bed solids. Air distribution to the fluid bed will be through a number of nozzles located in the bed support plate. Average superficial velocity above the bed at the point of fuel and limestone feed shall be between 1.2 to 3.7 m/second 4 to 12 fps at bed temperature and mix zone pressure. The pressure drop through the air distributor plate shall be 3.7 kPa 15 inches water gauge minimum. The walls of the fluid bed combustor shall be constructed of water-cooled tubes which form a part of the steam water circuit of the boiler. These walls shall be of membrane wall type of construction. The distributor shall be designated to assist with removal of large tramp material, where expected.

2.6.7 Bed Material Letdown System

The bed material letdown system shall be capable of removing and cooling solids from the bed including spent sorbent, unfired fuel, bottom ash, rocks, and debris. The system shall be designed to operate continuously and to cool all the solids going to disposal to 135 degrees C 275 degrees F or less. The system shall be sized to continuously remove at least 80 percent of the total solids generated from the boiler, unless otherwise approved. The design of the bed letdown system shall include personnel safety considerations such as prevention of spillage of hot bed material from the unit.

2.6.8 Burners and Fuel Piping

The burners and burner equipment shall be suitable for continuous service. Parts subject to severe wear or deterioration shall be replaceable with a minimum of dismantling. All valves or controls shall be mounted outside the boiler front and air housing. The burner design shall provide positive and uniform mixing of the air and fuel at all loads, and shall produce sufficient turbulence to preclude stratification. The burner design shall permit the firing of No. 2 fuel oil. In-duct/over-bed burners shall be of the air atomizing type. The burners and/or ignitors shall have an aggregate capacity capable of bringing a cold unit up to ignition temperature using either precalcined limestone or spent bed material in 4 hours for AFBs, and 8 to 12 hours for CFBs, depending upon refractory limitations. Equipment for remote positioning shall be furnished, if required, of each burner gun at either the fully retracted or fully inserted position. The positioning equipment shall be air operated; shall include limit switches to indicate the position of the gun and all necessary drives, linkages, and mechanisms; and shall automatically purge the fuel from the guns before retracting.

2.6.9 Air Distribution System

The air distribution system shall provide uniform air distribution to the fluid bed under any mode of operation. The system must also meet the mechanical and structural requirements of the boiler such as bed material dead load support, effective seal with the enclosure wall, and nonsifting

air nozzles.

2.6.10 Mechanical Collector and Solids Recycle System for AFB Boilers

A mechanical cyclone dust collector at the outlet of the boiler shall be provided. The mechanical dust collector shall be of the high efficiency multicyclone type designed for maximum operating temperatures encountered under all operating conditions. The collectors shall be designed to resist erosion and minimize plugging, shall be gas-tight, and shall have a collection efficiency of 85 to 95 percent on particles greater than 20 microns aerodynamic diameter, depending upon the recycle rate selected by the manufacturer. No refractory lining will be acceptable in the mechanical dust collector. The collection hopper shall have a valley angle of at least 60 degrees below the horizontal. The line carrying recycle solids back to the bed shall be fabricated of carbon steel with an allowance for wear and be installed at an angle of no less than 60 degrees below the horizontal. The solids collection hopper and dipleg shall be provided with pressure differential measurement to indicate pluggage. The design shall include provisions for sampling of recycle solids hopper contents. The hopper shall be fabricated of material capable of enduring the conditions imposed by a flue gas atmosphere. Provision for continuous disposal of ash from the recycle hoppers shall be provided.

2.7 IGNITION OIL SYSTEM

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NOTE: Wherever light oil is required as a support and/or ignition fuel, a complete ignition oil system must be provided. The system should include two full-size rail/truck unloading pumps, capable of unloading a rail shipment in one 8 hour shift or a truck shipment in 1 hour; one ignition oil storage tank capable of storing either 88 hours continuous plant ignition fuel demand or one rail shipment, whichever is larger; two full size ignition oil supply pumps per boiler unit, each capable of supplying the maximum ignition oil demand for each boiler unit; and one ignition oil day tank per boiler unit capable of storing 8 hours of continuous boiler ignition oil demand. Both the ignition oil transfer and boiler ignition supply pumps should be centrifugal type, where allowed by suction conditions and discharge flow/pressure requirements; otherwise, positive displacement pumps shall be used.

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2.7.1 Ignition Oil Pumps

Ignition oil pumps shall be furnished as duplex types assuring 100 percent standby. Pumps shall be provided complete with coupling, coupling guard, and electric motor shop-mounted and aligned on a common skid.

2.7.2 Burners

Where indicated and specified, each boiler shall be provided with oil-fired burner or burners. The burner assembly and control systems shall conform to UL 296, UL 726 and NFPA 85, except as otherwise specified. Supervised manual semiautomatic and fully automatic combustion safety controls shall conform to, NFPA 85 and ASME CSD-1.

2.7.3 Aboveground Oil Storage Tanks

Aboveground oil storage tanks and associated piping systems shall be in accordance with Section 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS.

2.7.4 Underground Oil Storage Tanks

Underground oil storage tanks and associated piping shall be in accordance with Section 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS.

2.8 COMBUSTION CONTROL EQUIPMENT

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NOTE: Subparagraphs describing inapplicable types of combustion control equipment will be deleted. Positioning type combustion control equipment will be specified for boilers with capacity of 13.2 MW 45,000,000 Btuh or less. Metering type equipment will be used for larger boilers. Positioning type controls with oxygen compensation may be furnished for boilers with capacity of 13.2 MW 45,000,000 Btuh or more in lieu of metering type. Oxygen compensated controls may be specified for boilers having output capacities of 7.3 MW 25,000,000 Btuh and greater if a life cycle cost analysis indicates it to be favorable.

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Combustion control equipment shall be provided as a system by a single manufacturer. An automatic combustion control system shall be installed for each boiler in accordance with the manufacturer's recommendations. The controllers shall be located on the boiler room panel specified in paragraph BOILER ROOM PANELS AND INSTRUMENTS. The equipment shall operate either pneumatically, electrically, or electronically. Pneumatic control systems shall conform to CAGI B19.1. Air filter regulator sets shall be installed at each control valve and transmitter in the system. The master air filter regulator set on the control panel shall be of the dual type where one side can be cleaned and repaired while the other is in operation. Exterior control air piping and devices shall be protected from freezing by use of a regenerative desiccant dryer. Each system shall be provided with a selector switch or other means of manual control of the firing rate when required. Electrical control devices shall be rated at 120 volts and shall be connected as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Operating and limit controls shall be wired to interrupt the ungrounded circuit conductor. [Steam and energy generating equipment shall include instrumentation and sufficient metering for accountability interface with a future Energy Monitoring and Control System (EMCS).]

2.8.1 Positioning Type

Positioning type combustion control equipment shall be capable of maintaining boiler steam pressure within plus or minus 2 percent of the set pressure over the complete range of boiler operation. The system shall maintain excess air within plus or minus 10 percent of the original control setting. The efficiency will be maintained without appreciable manual adjustment. The system shall be capable of maintaining the specified pressure provided that the load does not exceed a 15 percent per

minute change in capacity at any one time. The master transmitter shall be connected to the main steam header where the steam pressure is to be controlled. The signal transmitted from this point to the master controller shall be a function of steam pressure. On multiple boiler installations, a means shall be provided to base load on individual boilers while on automatic, and each boiler unit shall be individually controlled. Provision shall be made on the control system for adding on other boilers to the system with only minor wiring or piping changes on the panel. The fuel-to-air ratio on this system shall be adjustable from one knob that indicates increase and decrease of air in proportion to fuel. The range of this adjustment shall be limited to prevent operation below safe combustion limits.

2.8.2 Metering Type Combustion Control Equipment

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NOTE: This paragraph will be deleted if controls with oxygen compensation specified in paragraph COMBUSTION CONTROLS WITH OXYGEN TRIM are used.
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2.8.2.1 Fuel-Flow, Air-Flow Type Combustion Control

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NOTE: This paragraph will be used for spreader stokers.
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[Fuel-flow, air-flow type combustion control equipment shall be the proportioning and reset type, and shall position the fuel feed or air flow and then adjust one to the other by a ratio controller operating from air flow and fuel feed. The controls shall include fuel-flow measuring elements and air-flow measuring elements. Separate fuel feed and air-flow controllers shall be panel-mounted along with a fuel-to-air ratio controller. The air-flow index shall be set by a measuring element in the air stream. Systems controlling fuel and air by line shafting and mechanical connections will not be acceptable.]

2.8.2.2 Two Element (Steam Pressure, Steam Flow)

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NOTE: If underfeed, traveling grate, or vibrating grate stokers are specified, use this paragraph.
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[Two element (steam pressure, steam flow) combustion control equipment shall be the proportioning and reset type, and shall control the fuel feed or air flow either in parallel or series. The controls shall include measuring elements for steam flow, fuel feed, and air flow. Separate steam pressure, fuel flow, and air flow controllers shall be panel-mounted along with a fuel-to-air ratio controller. The actual steam flow shall be measured by an orifice or other flow measuring device in the steam line. The air-flow shall be set by a measuring element in the combustion air stream. Systems controlling fuel and air by line shafting and mechanical connections will not be acceptable.]

2.8.2.2.1 Master Pressure Transmitter

A master pressure transmitter shall be provided and connected to the main

steam header at a point where the steam pressure is to be controlled. The master controller, which is located on the panel, shall load the various individual boiler controllers according to steam pressure changes. On multiple boiler installations, an operator station shall be provided to base load or bias each individual boiler while keeping its fuel and air controllers on automatic. This boiler master station shall be mounted on the control panel between the master controller and the remainder of the control system. Indicators shall be provided to show the loading impulse from the master controller to the boiler master station and each boiler master station output.

2.8.2.2.2 [Fuel Feed] [Steam-Flow] Transmitter

A [fuel feed] [steam-flow] transmitter shall be provided for each boiler and shall feed a signal to a fuel feed controller. Each fuel feed controller shall be loaded by the master controller for the rate of [fuel feed] [steam-flow] corresponding to the rating of the respective boiler. The controller shall operate the fuel device controlling the rate of fuel feed. The controller shall incorporate proportional plus reset control features.

2.8.2.2.3 Air-Flow Transmitter

Air-flow transmitter shall be provided for each boiler. The air-flow controller shall control from this signal or in such other manner as to maintain a predetermined ratio of air to fuel. An indicator shall be provided showing the amount of any manual adjustment to the air-to-fuel ratio. The controller shall have proportional plus reset modes of control.

2.8.2.2.4 Automatic Controller

Each automatic controller shall have a manual-to-automatic station and indicator on the control panel that will provide for selecting either automatic control or manual control and also will provide for manual operation. The manual controls shall be arranged to allow any one or more of the functions of the control system to be controlled manually while the other functions remain on automatic control. The manual control station shall be complete with all necessary indicators and provide bumpless balanceless transfer from automatic control to manual control and vice versa.

2.8.2.2.5 Power Units

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

2.8.2.2.6 Furnace Draft Controller

Furnace draft controller of the modulating type shall be provided with each boiler. The draft controller shall be designed to maintain automatically within 2.5 Pa 0.01 inch water column the desired furnace draft for which it has been set manually. The draft controller shall fix

the position of the boiler outlet damper through a power operator. An indicator shall be provided to show the amount of any manual adjustment that might be made. The draft regulator shall be equipped with a manual-automatic switch.

[2.8.3 Combustion Controls with Oxygen Trim

Flue gas oxygen trim may be furnished with combustion controls specified. An oxygen analyzer and oxygen controller shall be provided. The oxygen controller shall be of the proportional band and reset type and shall feed its signal in a biasing fashion into the fuel-to-air ratio system. The oxygen setpoint shall be a function of boiler load with operator biasing capability. The amount of oxygen controller trim shall be limited to prevent potentially hazardous conditions caused by equipment failure or misoperation.

]2.8.4 Boiler Limit Controls

a. Two low-water cutoffs shall be provided to prevent startup and to shutdown the fuel if the boiler water level is below the preset safe level. The primary interlock may be automatic or manual reset type. The secondary interlock shall be the manual reset type.

b. A high-pressure limit switch shall be provided to shutdown the fuel when steam pressure exceeds the preset safe limit. This equipment shall be additional to the operating controls.

c. A draft loss interlock and air-flow switch or a suction switch shall be provided to prevent startup and to shutdown fuel supply when air is inadequate to safely support combustion. Limit and operating controls shall be provided for operation on a two-wire grounded branch circuit.

d. Safety interlocks required by the applicable NFPA standard shall be provided.

2.8.5 Burner Control/Fuel Safety System

2.8.5.1 Design Requirements

The control system shall be of the microprocessor-based (distributed digital or programmable controller) or relay type. A dedicated hardwired insert panel shall be furnished for monitoring and operator interface with the burner control/fuel safety system. This insert panel shall also provide the operator with direct fuel tripping capability in emergency situations. The burner control system shall be sufficiently subdivided to permit inservice checkout and maintenance without impairing the reliability of the overall control system. The logic cabinets shall include status indicating lights for logic inputs and outputs, and for monitoring availability of control power to subsystems as required to facilitate troubleshooting. Indication of equipment status and system permissives shall be provided at the operator interfaces. Where common power supplies internal to the system are furnished, a full-capacity on-line backup supply shall be included. Failure of either power supply shall be alarmed.

2.8.5.1.1 Maintenance and Reliability Requirements

In general, maintenance shall be accomplished on-line and without imposing any special restrictions on overall plant operation. Diagnostic routines,

interchangeable electronic cards or boards, and clear written procedures shall be provided. Reliability, both software and hardware, shall be incorporated into the system design. This shall include redundancy, loop distribution, component specifications and testing, and quality control to assure the highest level of system reliability.

2.8.5.1.2 Adverse Electrical Conditions

Equipment shall be capable of operating as specified and without damage within the electrical environment of the plant. This environment includes high-voltage, high-frequency surges caused by electromechanical equipment, energy coupled between conductors by capacitance and mutual inductance, and imperfect grounds. Input and output isolation, shielding, separation of circuits, surge suppression, or other measures which may be required to meet these provisions shall be provided. Inputs, outputs, and other connections shall meet the surge to withstand requirements of IEEE C37.90.

2.8.5.2 System Design

The burner control system shall be compatible in all respects with the boiler and auxiliary equipment. The system design shall meet the requirements specified in NFPA 85. The burner control system shall incorporate a continuous purge of the furnace to insure that the boiler is free of any accumulation of combustibles. The burner control system shall also supervise the operation of the fuel-air equipment associated with the pulverizer and fuel oil burners. The system shall accept operator commands and, if the required permissives are met, perform the required operation. Equipment shall be continuously monitored, and any deviation shall be alarmed while the system either corrects the deviation or shuts down equipment as necessary to avoid hazardous furnace conditions or equipment damage. The system shall monitor the operation of the fuel equipment and, if the equipment fails to respond to commands from the burner control system, the equipment trip sequence shall be initiated. Indications shall be provided to allow the operator to determine the equipment which initiated a trip of fuel equipment. Tripped equipment shall be successfully shut down before reset of the trip is permitted. The burner control system shall include a fuel safety subsystem which shall include a master fuel trip (MFT) system, ignitor fuel trip system, and pulverizer mill trip systems. Each system shall include a hardwired relay which may be directly operated from the operator insert panel. Inputs to the MFT shall include, in addition to those associated with the burner control, those that are required to provide overall boiler protection. Also, the system shall interface with the combustion control system to position and monitor devices for startup and shutdown which are normally modulated during on-line operation. The burner control system shall be designed to operate reliably and to minimize the number of false trips.

2.8.5.3 System Functional Requirements

2.8.5.3.1 Operating Modes

The operator shall have the responsibility for initiating the start and stop sequence listed below. Once initiated, the burner control system shall automatically place the mill or oil burner in service or remove it from service. The steps, each of which requires operator initiation, are:

(1) Purge

(2) Igniter control

(3) Pulverizer control

(4) Feeder control

2.8.5.3.2 Furnace Purge and Boiler Monitor

The furnace purge control shall incorporate prelight off and post purges of the furnace to ensure that the boiler is free of any accumulation of combustibles. Completion of the furnace purge shall be indicated to the operator, after which the operator shall reset the master fuel trip relay. A furnace purge shall be required on any master fuel trip. The boiler monitor shall prevent starting any fuel equipment if the furnace firing permissives are not met. The furnace purge control shall provide indications to the operator of the status and the progress of the furnace purge. Permissive indications shall be extinguished when the MFT is reset.

2.8.5.3.3 Mill Start-Stop Sequences

The operator shall start and stop the mill in three steps (ignitor, pulverizer, feeder) following fixed sequences. The system shall be capable of transferring between the startup and shutdown sequences at any time. Each mill shall be monitored and should any unsafe conditions occur, that mill shall be tripped. A mill first out indication shall be provided to indicate the initiating cause of trip. The first out indication shall be deleted only upon reset of the mill trip relay. Startup and shutdown sequence indications shall be provided to allow the operator to follow the progress of the mill startup or shutdown sequences. These indications shall show the next step to be performed, as well as the progress through the sequences.

2.8.5.3.4 Ignitor Control

An ignitor group consists of the ignitors associated with a pulverizer burner group. Ignitors associated with a burner group shall be controlled from a separate electropneumatic ignitor control package. Sequential starting of ignitors between burner groups shall be provided. The ignitors associated with a burner group shall be started and stopped from the insert panel and local push buttons. An ignitor fuel trip (IFT) first out indication shall be provided to indicate the initiating cause of the IFT. This indication shall be extinguished only when the IFT relay is reset.

2.8.5.3.5 Fuel Safety Subsystem

The fuel safety subsystem comprises the MFT system, IFT system, and pulverizer mill trip (MT) systems. A mill trip system shall be provided for each mill. Each fuel safety system shall provide the protection for its respective fuel and shall include a dedicated hardwired relay which may be directly operated from the operator insert panel. The master fuel trip system shall provide overall boiler protection, shall also include a dedicated hardwired relay, and shall directly trip all other fuel safety system relays. The system shall be designed to deenergize to trip.

2.8.5.3.6 Flame Monitoring

Individual self-checking flame scanners are required for each burner. Ignitor flame safety devices shall discriminate individually from any

flame that may exist at other burner locations. Burner flame shall be discriminated individually from the associated ignitor flame and any other flame that may exist in the furnace. Ignitor and burner flame discrimination shall cover the range from startup to full load operation. Blocking interlocks from closed valves in flame discrimination circuits to avoid false flame indication are not acceptable. If required to obtain satisfactory flame discrimination, extended tube scanners shall be included. Individual flame detector output level indicators are required. Provisions for cooling and cleaning shall be provided, if required.

2.8.5.3.7 Enclosures

The system logic cabinets shall contain control devices, power supplies, circuit protective devices, cable plugs, and terminal blocks. Spare space shall be provided to accommodate a minimum of 20 percent additional devices. The cabinets shall be accessible from both front and back, and each shall have gasketed hinged doors with latches. Each door shall not exceed 600 mm 24 inches in width. Natural draft cooling of the control system cabinets is preferred. If cabinet cooling fans are furnished, the loss of any fan shall be alarmed.

2.8.5.3.8 Local Termination Boxes

The system shall include local junction boxes, one at each burner level and one at each pulverizer. Burner level junction boxes shall contain separate push buttons and indicating lights for local control of each ignitor group. In addition, the terminal boxes shall contain terminals for field wiring, internal wiring, cable connectors for intersystem wiring, circuit breakers and, if required by the system, relays and reversing starters. Terminal boards for field wiring shall include 20 percent spare connections. Also, the system shall include local pulverizer junction boxes for terminating field wiring associated with each mill. These junction boxes shall meet the requirements described above, except local control is not required.

2.8.5.3.9 Interconnecting Cable Requirements

Interconnecting cables between the logic cabinet, insert panel, local burner junction boxes, and local mill junction boxes shall be via prefabricated plug-in cables, including connectors. Flame scanner cables shall also be furnished.

2.8.5.3.10 Buffered Output Signals

Output signals required for tripping, control, and monitoring shall be fully isolated from each other. The isolation shall be such that an open or short circuit in the related equipment shall not affect other control systems.

2.9 BOILER ROOM PANELS AND INSTRUMENTS

2.9.1 Instrument Control Panel

Instrument and control panel shall be sized to contain all controls, instruments, gauges, and meters. The panel shall be free-standing with faceplate of not less than 4.8 mm 3/16 inch steel, properly reinforced, and shall be finished with the manufacturer's standard finish coating. The units shall be mounted flush on the panel as far as practicable.

Controls, instruments, and other equipment shall be flush mounted, each fitting neatly into a cutout, and completely covering the cutout and any mounting screws or bolts. The back of the panel shall be enclosed with sheet metal and with adequate removable access panels or doors for maintenance and removal of any unit without interfering with other units. Proper latching equipment and hardware shall be provided. Each recorder, indicator, and control unit shall be identified with nameplates securely fastened to the panel. Nameplates shall be black over white laminated plastic with the lettering penetrating the black surface to expose the white. Nameplates shall be mounted not more than 25 mm 1 inch below the instrument or gauge, on the centerline. The panel shall have continuous, rapid-start, fluorescent light fixtures mounted with reflectors providing suitable shielding to illuminate controls, instruments, gauges, and meters. Field piping connections shall terminate in one bulkhead-mounted manifold, located to conform with the installation requirements of the system. Field electrical wiring shall terminate in a color-coded terminal strip so located as to conform with the installation requirements of the system. Electrical tubing or piping connections to controls, instruments, or other devices on the panel shall be inside the panel and not visible from the panel front. A suitable plug-in strip shall be provided in the rear of the panel for any required plug-in electrical connections of the instruments. Necessary transformers, separate relays, switches, and fuses shall be installed in a fully enclosed junction box. A fused safety switch shall serve the 120-volt power supply required for control circuits. If a pneumatic control system is provided, the panel shall include duplex air supply filter and regulator set mounted on the rear of the panel with properly identified pneumatic terminal blocks and low point drain. No high-pressure lines will be allowed to enter the panel. [If packaged boiler burner units with integral controls are furnished, the control equipment may be mounted on a separate free-standing panel for each boiler. Controllers and indicators specified or required shall be panel-mounted and tested at the factory complete with relays, transformers, switches, wiring, valves, piping, and other appurtenances. Wiring and piping within the panel shall be color-coded or otherwise identified.]

2.9.2 Indicators

Indicator shall be flush mounted with a vertical scale of 100 to 150 mm 4 to 6 inch length. Indicators may be either electronic or pneumatic with zero adjustment, receiving standard signals form locally mounted transmitters. Scales shall be in engineering units with an accuracy of plus or minus 1 percent.

2.9.3 Recorders

Recorders shall be servo mechanism type, or multiple pen type. [Circular] [Strip] chart type shall be provided. Minimum chart width is 100 mm 4 inches. Accuracy shall be plus or minus 0.5 percent. Each pen shall have a separate scale calibrated in engineering units. Chart drive shall be 120 volts ac. One year's supply of chart paper shall be provided.

2.9.4 Panel Display

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NOTE: Steam flow meters will be specified for boilers having a continuous steam capacity of 4,540 kg 10,000 pounds or more per hour and shall be integrating type where indicated. Feedwater meter

will be provided on individual boilers not having steam flow meter.

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As a minimum, the following parameters shall be displayed on the panel:

Pressure	Indicator	Recorder Point
Main steam header	X	X
Boiler drum	X	
Feedwater	X	X
Instrument air	X	

Draft	Indicator	Recorder Point
Windbox	X	
Furnace	X	
Boiler gas outlet	X	
ID fan inlet	X	

Temperature	Indicator	Recorder Point
Main steam		X
Boiler gas outlet		X
Windbox		X
Feedwater		X

Level	Indicator	Recorder Point
Boiler drum		X
Bunker or silo	X	

Flow	Indicator	Recorder Point
Main steam (including totalizer		X
Feedwater		X
Air		X

Flow	Indicator	Recorder Point
Fuel		X
Analyzers	Indicator	Recorder Point
Flue gas opacity		X
Flue gas oxygen		X

2.9.5 Panel Piping and Wiring

High-pressure and high temperature values shall be pneumatically or electrically transmitter, or both, to the panel. Pneumatic signals shall be 21 to 103 kPa 3 to 15 psig. Piping connectors to indicators shall be 6 mm 1/4 inch OD copper tubing conforming to ASTM B68/B68M. Flow signals shall be transmitted either pneumatically or electrically to the panel-mounted receiver. Copper tubing connections and electric wiring shall be run to a terminal block located on the inside of the panel front near the bottom. Wiring shall be terminated at an identified terminal strip. Wiring shall be suitable for boiler room requirements and installed according to NFPA 70.

2.9.6 Pilot Lights

Pilot lights shall be assembled in a factory-built cabinet, suitable for flush mounting in cutouts in boiler control panel, complete with extruded trim, clamps, and sheet metal rear housing, and finished in baked black enamel. Lens shall be white plastic and engraved in black ink. Lettering shall be 19 mm 3/4 inch high and black. Two lamps per pilot shall be provided and independently wired. Lamps shall be 6 watts, 24 volts dc, S-6 incandescent type, supplied with color caps, one red and one green per pilot light. Lens bezels shall be black unless otherwise indicated.

2.9.7 Clock

The clock shall be electric synchronous motor type. The clock shall be for surface mounting and suitable for operation on 115-volt, 60 Hz single-phase electric service. The clock shall have a white dial, easy-to-read black numerals, black hands, red sweep second hand, and external manual reset knob at bottom of case. The motor gear train shall be sealed in a permanent oil bath. The clock dial shall be 381.0 mm 15 inch size.

2.9.8 Alarm Annunciator Panel

Layout of annunciator panel shall be as shown. Panel shall consist of a flush-mounted cabinet, mounting trim with clamps, removable rear cover, and alarm modules. Cabinet shall be finished with black baked enamel, aluminum trim, and black alarm bezels. Nameplate size of alarm modules shall be nominal 70 mm 2-3/4 inches high by 75 mm 3 inches wide in translucent white acrylic plexiglass and all nomenclature shall be engraved on front surface in black lettering. Plug-in alarm module shall include epoxy circuit board, one reversible plug-in relay, one general-purpose plug-in relay, relays with dust covers, two selector switches for relay contact selection, and two lamps wired in parallel at 24 volts dc, 6 watts. Flasher module shall be mounted and prewired with

silence and test pushbuttons. Alarm horn shall be remotely mounted and of general-purpose construction. Input voltage shall be 120 volts ac, 60 cycle. Power supply of 120 volts to 24 volts dc output of volt-ampere capacity shall be provided to suit load. Alarm sequences of panel shall provide for "first alert" sequence, with manual reset and ringback sequences. Annunciator panel shall be prewired internally to a rear terminal strip.

2.9.9 Combustion Control Components

Components shall conform to the requirements of paragraph COMBUSTION CONTROL EQUIPMENT.

2.9.10 Steam and Feedwater Flow Measurement

Flow nozzles shall be provided to measure the steam flow from each boiler and each main steam header outlet. Orifice plates shall be provided to measure feedwater flow to each boiler. Nozzles and orifice plates shall be flange-mounting type and made of stainless steel. Orifice plates shall be of the square edge, concentric, paddle type designed for flange taps. Minimum straight pipe runs shall be in accordance with AGA XR0603. Condensate pots shall be provided for steam service.

2.9.11 Flue Gas Opacity Monitor

A flue gas monitoring system shall provide continuous measurement, indication, and recording of smoke opacity from each boiler. The stack units shall include a light source and a light detecting or receiving unit mounted in the stack or main breeching as recommended by the manufacturer. The control or transmitter unit shall have electronic solid-state circuitry and meter or digital type indicator, and provide an output signal of 4 to 20 mA dc for 0 to 100 percent opacity. In addition, the control unit shall have calibration and alarm adjustments for compliance with Federal, State, and local environmental regulations. The control or transmitter unit and recorder shall have dust-tight metal enclosure. A purging air system shall be provided to clean light source lens and light detector lens. The control unit shall have adjustable alarm output contacts for various smoke densities.

2.9.12 Sample Cooler

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

2.9.13 Oxygen Analyzer

If oxygen compensation controls are furnished, an oxygen analyzer shall be provided to indicate, record, and control the percentage of net excess oxygen in, and the average temperature of the flue gas leaving, the boiler. The oxygen analyzer shall be of the direct probe type utilizing an in situ zirconium sensing element. The element shall be inserted

directly into the process flue gas stream and shall directly contact the process gases. The sensing element shall be contained within a protective shield mounted to the ductwork by an adapter plate, furnished by the manufacturer. The analyzer shall be equipped to allow daily automatic calibration check without removing the analyzer from the process. That is, sample gases may be injected directly on the sensing element while the analyzer is in the process. The analyzer shall include any temperature compensation of control required. The output signal range shall be 4 to 20 mA dc and shall represent 0 to 10 percent as a linear function.

2.9.14 Continuous Blowdown

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

Blowdown system will be deleted if not required for the project.

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Package type blowdown system shall be rated as indicated. The system shall automatically proportion blowdown to amount of makeup. The unit shall include [the heat exchanger's flow control valve,] strainer, sample cooler (if required), solenoid valve, and surge tank. [An extra-heavy blowdown heat exchanger shall be provided. Tubes shall be of stainless steel. A removable tube bundle shall be provided with U-tubes having bends twice the thickness of the tubing. A rear baffle shall support all tubes at the return bend.] A sample cooler shall be installed so that shell and tubing can be removed without disturbing piping or mounting. Continuous blowdown valve shall be the manual proportioning type fabricated of corrosion-resistant steel. The valve shall be equipped with a micrometer dial and pointer to indicate the proportional setting.

2.9.15 Continuous Emissions Monitoring

****

NOTE: A continuous emissions 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 megawatts 10 million BTU/HR or greater. A CEMS may also be required by state or local laws. If a CEMS is necessary the designer shall review the CAAA and the relevant state or local law early in the project to allow time to incorporate the required CEMS specification and to determine which flue gas emissions will be included in the required reports. Before acceptance of the installation, the Contracting Officer shall be furnished a written test report which provides documentation that the CEMS equipment has passed factory and field certification tests required by federal, state and local regulations. The investigation will determine if the reported values may be calculated or should be direct measurements. Fill in the data to state what method of measurement or calculation will be utilized for the determination of the report variable.

Emerging flue gas flow monitor technologies are available. The traditional differential pressure technique specified uses familiar equipment that can be maintained by plant personnel. This type of measurement device has reliably satisfied regulatory requirements. The possible use of other technologies should include a thorough investigation of flue gas flow monitor regulatory requirements and in-house maintenance capabilities.
****

a. Continuous emissions monitoring system (CEMS) equipment shall be provided as a system by a single manufacturer. A CEMS, meeting the requirements of applicable federal regulations, State of [_____] and local regulations, shall be provided for each boiler in accordance with manufacturer's recommendations and under the direct supervision of the CEMS equipment manufacturer.

b. The reported data shall include [sulfur dioxide (SO2)] [oxides of nitrogen (NOx)] [carbon dioxide (CO2)] [particulate matter (PM)] and other information required by federal, state, and local regulations. SO2 reporting shall be based on [analyzer measurement] [fuel flow and percent sulfur calculation] [daily heat input calculation]. Nitrous oxides, carbon dioxide and particulate matter reporting shall be based on analyzers.

c. The CEMS equipment shall include the central processing unit, printer, hard disk drive, and floppy disk drive. The floppy disk drive shall function as a recorder. The manufacturer shall provide the software to generate the required reports in a format acceptable to the federal, state and local regulatory agencies. The operator interface to the CEMS equipment shall be via CRT screen.

2.10 WASTE HEAT RECOVERY EQUIPMENT

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NOTE: Economizer or preheater will be selected to be compatible with pollution control equipment being utilized.
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Each boiler shall be equipped with [an economizer] [an air preheater]. Units may be separate from or integral with the boiler and shall be complete with insulation and jackets, casings, supports and access doors, and shall have provision for tube or tube bundle removal and for cleaning. Soot blowers shall be provided as specified in paragraph BOILERS.

2.10.1 Economizers

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

condition. Economizer tube metal temperature shall be above the maximum flue gas dewpoint for the fuel being fired under all load conditions.

2.10.2 Air Preheaters

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

2.11 DRAFT FANS

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NOTE: Where fans are not protected by electrostatic precipitators or baghouse filters on boilers of 4540 kg per hour 10,000 pounds per hour and larger, provide liners for scroll sheets and rotor blades.

Induced draft fan outlet dampers may not be required in single fan/single boiler installations, except to eliminate the stack effect during outages.

****

Centrifugal fans conforming to AMCA 801 [Type I] [Type II] [forced-draft] [and] [induced-draft] shall be furnished as an integral part of boiler design. Fans shall be centrifugal with [backward curved blades] [radial tip blades] [or] [axial flow type]. Each fan shall be sized for an output volume and static pressure rating sufficient for pressure losses, excess air requirements at the burner or grate, leakages, temperature and elevation corrections for a dirty boiler with worst ambient conditions, all at full combustion to meet net rated output at normal firing condition. In addition, fan sizing shall include margins of 10 percent volume and 21 percent static pressure, plus margins of 5 degrees C 10 degrees F for forced draft fans and 22 degrees C 40 degrees F for induced draft fans. Induced-draft fans shall be designed for handling hot flue gas at the maximum boiler outlet temperature adjusted for boiler surface fouling. [Induced draft fans shall be provided with outlet dampers.] Noise levels for fans shall not exceed 85 decibels at 914.4 mm 3 foot station. Fan bearings shall be [air-cooled] [or] [water-cooled], and backward curved fan blade type with bearings not requiring water cooling may be of the self-aligning antifriction type. [Scroll sheets and rotor blades shall have liners.]

2.11.1 Draft Fan Control

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NOTE: Variable speed control, inlet vane control, and inlet damper control are, in descending order of efficiency, capable of control draft fan conditions. The choice is based on economics. However, in erosive services, inlet vane control is not desirable.

****

Forced-draft centrifugal fans shall have [inlet vane controls] [variable speed control] where indicated. Induced-draft centrifugal fans shall have [inlet vane control] [inlet damper control] [variable speed control]. [Axial propeller fans shall have variable propeller pitch control.] Inlet vanes or dampers shall be suitable for use with combustion control equipment.

2.11.2 Draft Fan Drives

****

NOTE: Where motor starters for mechanical equipment are provided in motor control centers, delete the reference to motor starters.

Steam driven boiler auxiliaries will not be used unless the exhaust steam can be utilized completely. Reference to steam drives will be deleted if inapplicable for the equipment specified.

****

Fan shall be driven by [an electric motor] [or] [a steam turbine]. [Electric motor shall be [drip-proof] [totally enclosed nonventilated] [totally enclosed fan-cooled] [totally enclosed fan-cooled, suitable for installation in a Class II, Division 1, Group F, hazardous location conforming to NFPA 70].] [Motor starter shall be magnetic [across-the-line] [reduced voltage start] type with [general-purpose] [weather-resistant] [watertight] [dust-tight] [explosion-proof] enclosure and shall be furnished with four auxiliary interlock contacts.] [Steam turbines shall operate properly in a steam pressure range of [_____] Pa psig with steam back pressure of [_____] Pa psig. Turbines shall have horizontally-split, centerline supported casings, water-cooled bearing housings with ring-oiled, babbitt-lined, bronze packed sleeve bearings. Turbines shall also be equipped with a mechanical shaft speed governor and valve, and independent emergency overspeed governor and trip valve, reed tachometer, constant pressure type governor, insulation with removable metal jacket, oil-sight glasses with guards, removable stainless steel steam strainer [without disconnecting piping], any special wrenches and tools required for servicing turbine, and a sentinel warning on the exhaust casings. Turbines shall conform to NEMA SM 23.]

2.12 AIR DUCTS

Air ducts connecting the forced-draft fan units with the plenum chamber shall chamber shall be designed to convey air with a minimum of pressure loss due to friction. Ductwork shall be galvanized sheet metal conforming to ASTM A653/A653M. Ducts shall be straight and smooth on the inside with laps made in direction of air flow. Ducts shall be externally braced and shall be so installed and anchored as to be free of vibration. Access and inspection doors shall be provided as indicated and required. Ducts shall be constructed with long radius elbows having a centerline radius 1-1/2 times the duct width, or where the space does not permit the use of long radius elbows, short radius or square elbows with factory-fabricated turning vanes may be used. Duct joints shall be substantially air-tight and shall have adequate strength for the service, with 38.1 x 38.1 x 3.2 mm 1-1/2 x 1-1/2 x 1/8 inch structural steel angles used where required for strength or rigidity. Duct walls thickness shall be as follows:

Ducts, Maximum Dimension	Steel Sheet, Minimum Thickness
Up thru 1.5 m (60 inches)Up through 60 inches	1.519 mm (16 gauge)16 gauge
1.6 m (60 inches) 61 inches and larger	2.657 mm (12 gauge)12 gauge

2.13 BREECHING

Breeching shall be constructed of not less than 3.416 mm 10 gauge steel sheets conforming to ASTM A36/A36M. Breeching shall be adequately reinforced and braced with structural steel angles not smaller than 50 x 50 x 6.4 mm 2 x 2 x 1/4 inches, and all joints and seams in the sheets and angles shall be welded. Expansion joints shall be installed as indicated and as required to suit the installation and shall be flexible type requiring no packing. Breeching shall have angle flanges and gaskets for connection to boilers, fans, equipment, or stacks. Breeching connections shall be gas-tight and be caulked tight all around and sealed with cement to form an air-tight joint. Clean-out openings of suitable size and at approved locations shall be provided for access to all sections of the breeching and shall have tight-fitting, hinged, cast-iron doors with cast-iron frames. Plastic materials polyetherimide (PEI) and polyethersulfone (PES) are forbidden to be used for vent piping for combustion gases.

2.14 STACKS

Stacks for individual boilers shall be self-supporting double-wall insulated type. Unless otherwise indicated, each stack shall be complete with structural steel base, base plates, anchor bolts and nuts, clean-out door, [induced-draft fan] [boiler] connection and a thermometer well. Stub stacks for packaged boiler units may be supported directly on the boiler providing the boiler structure is designed to accommodate such an arrangement. Insulation shall be suitable for sustained flue gas temperature of 480 degrees C 900 degrees F with intermittent temperatures up to 650 degrees C 1200 degrees F and the wall section shall provide a "U" factor of approximately 0.26. Stacks shall be fabricated of steel conforming to ASTM A242/A242M for both inner and outer shell. Inner shells of each section shall be provided with an air-sealed and concealed expansion and contraction device to allow for differential expansion of inner and outer shells. Stacks shall be extended above the roof to the height indicated. Plastic materials polyetherimide (PEI) and polyethersulfone (PES) are forbidden to be used for vent piping for combustion gases.

2.15 BLOWOFF TANK

Blowoff tank [shall be constructed of 28 MPa 4000 psi reinforced concrete as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE, and shall be fitted with a bolted steel manhole cover and frame. Blowoff pipe, vent pipe, and drain pipe to sewer shall be installed in pipe sleeves built into the concrete. The space between the pipe and sleeves shall be filled and caulked with lead wool or similar material to make a water-tight connection. The tank shall be divided into two sections by a baffle to form a sediment chamber] [shall be constructed of steel in accordance with NBBI NB-23 PART 1.]

2.16 PUMPS

2.16.1 Boiler Feed Pumps

Boiler feed pumps shall be sized and designed for the specific application. Pumps having a combined rating of flow and head that results in a wattage horsepower rating less than 185 kW 250 bhp shall be furnished to meet the design requirements of API STD 610. The pump shall be end-suction, top discharge and be supported at its centerline. Pump sizes with higher ratings than the above shall be horizontal-split case, multistage centrifugal pumps. Casing construction shall be either volute or diffuser design and shall also be supported at its casing centerline. All pump ratings shall have, nominally, an excess in capacity of 10 percent above the maximum continuous rating of the service. The required net positive suction head (NPSH) at the pump design flow, head, and speed shall not exceed 80 percent of the available system NPSH at the same flow, assuming a low level in the storage tank. The pump's suction specific speed shall not exceed 9000 at the pump's best efficiency point (BEP). The guaranteed NPSH requirements shall reflect 3 percent breakdown criteria. The pump's head-capacity (H-Q) curve shall be constantly rising to shutoff with no point of inflection. There shall be no restriction to operation at any point from minimum continuous flow to design flow.

2.16.1.1 Casings

Pumps shall have integrally cast suction and discharge flanges that shall be drilled to meet the design pressure of the application. The maximum operating temperature, for design purposes, of any feedpump shall not be less than 204 degrees C 400 degrees F. Casings shall be drilled, tapped, and provided with vent and drain connections. Pumps designed for this service shall not require cooling at ratings below 375 kW 500 bhp. This applies to both frame cooling or seal cooling. Below 375 kW 500 bhp, pumps shall employ antifriction radial and thrust bearings lubricated by flinger rings in a sealed housing. Seals shall be mechanical and air-cooled flush piping conforming to API STD 610, Plan 23. Above 375 kW 500 bhp, pumps shall employ a single cooling circuit for both cooling the oil being delivered by a forced oil system to sleeve radial bearings and a floating shoe thrust bearing, coupled with the seal coolers for both stuffing boxes. Mechanical seals shall also be provided. In both cases, stuffing boxes shall be site-convertible to a packed box. Leakage shall be no more than 25 mm/hour 25 cc/hr for a seal life of no less than 25,000 hours. Bearing rating shall be not less than 100,000 hours (L-10 life) at the point of maximum load, as defined by ABMA 9.

2.16.1.2 Base

Pumps shall be supported on structural steel bases that do not require grouting in order to impart strength to the pump for static and dynamic loading from the piping system. The bases shall be pitched to a low point drain. The complete pump and motor assembly shall be shop-aligned using shims on both the pump and the motor.

2.16.1.3 Couplings

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

2.16.1.4 Automatic Recirculation

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

All pumps shall be furnished with a self-contained automatic recirculation control valve that shall be sized for nominally 25 percent of the pump's BEP flow.

2.16.1.5 Turbines

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

2.16.1.6 Electric Motors

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

2.16.1.7 Shop Hydrostatic Testing

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

2.16.2 Condensate Pumps

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NOTE: If inadequate NPSH is available, the designer shall give consideration to substituting either a double suction or positive displacement pump.
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Condensate pumps shall be horizontal, end suction, single stage,

centrifugal, motor-driven pumps. Pumps shall have stainless steel shafts and bronze impellers. Pumps shall be provided with stuffing boxes. Lubrication shall be by splash oil with oil level sightglass provided. Pumps shall be subjected to the same tests specified for the Boiler Feedpumps.

2.17 CONDENSATE TANK AND ACCESSORIES

2.17.1 Condensate Tank

Condensate tank shall be designed for a working pressure of 103 kPa 15 psig and shall conform to ASME BPVC SEC VIII D1. The tank shall have a storage capacity equal to or greater than indicated and shall be installed complete with piping and accessories.

2.17.2 Feedwater Makeup Valve

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

2.18 HEAT EXCHANGERS

Heat exchangers shall be designed, fabricated, tested, and stamped in accordance with ASME BPVC SEC VIII D1. Additionally, heat exchanger designs shall meet the requirements of HEI 2623. Closed feedwater heater designs shall meet the requirements of HEI 2622. Heat exchangers shall be provided with relief valves as required by ASME BPVC SEC VIII D1 and the HEI Standards. Heat exchangers using service water shall be designed to have the service water inside the tubes. The exchangers shall be of straight tube designs with bolted full diameter access channel covers to facilitate tube maintenance as required. Return bonnets are acceptable when there are no tubeside nozzle connections at the far end. Materials of construction shall be all carbon steel, except the service water side which shall reflect the service water available. When the water quality permits, the tubes shall be stainless steel in accordance with ASTM A249/A249M, Grade TP 304, the remainder of the tube side shall be all carbon steel. When the service water is known to contain chloride levels harmful to stainless steels, the tubes shall be 90-10 Copper-Nickel in accordance with ASTM B111/B111M Alloy 706; the remainder of the service water side shall be as follows: tubesheets, monel-clad steel; channel covers, carbon steel lined with monel; channels and bonnets, monel. Fixed tubesheet designs are preferred when operating conditions do not impose a large differential movement that cannot be readily accommodated with a simple thin-wall metal bellows expansion joint. For larger differentials, a packed floating tubesheet with lantern ring is acceptable up to 1.03 MPa 150 psig design pressure. For pressures above 1.03 MPa 150 psig, a split ring floating head design shall be used. Heat exchangers using steam to heat domestic water or other fluids such as glycol-water mixtures or fuel oil shall have the steam in the shell side. The exchangers shall be of U-tube designs with bolted full diameter channel covers to facilitate tube maintenance as required. The tubesheet shall be the full diameter to match the shell flange and shall have sufficient threaded bolt holes so that a shell hydro test may be applied without the channel in place. Materials of construction shall be of all carbon steel with the exception of the tubes which should typically be specified as stainless steel in accordance with ASTM A688/A688M, Grade TP 304, stress relief annealed

temper with the U-bends stress relieved after bending. Fuel oil heaters shall have carbon steel tubes in accordance with ASTM A179/A179M and be furnished in the stress relief annealed temper with the U-bends stress relieved after bending. Feedwater heaters shall be of all welded construction with bolted full diameter channel covers to facilitate tube maintenance as required. The channel barrel shall be integral with the tubesheet and have an internal pass partition bolted cover design that shall be readily removable when the channel cover is removed. Pass partitions that are sealed with a gasketed groove in the channel cover are prohibited. Materials of construction shall be all carbon steel except the tubes. Pressure boundary material shall be in accordance with ASTM A516/A516M, Grade C, when plate material is required, or ASTM A350/A350M when forging material is required. Shroud plate material for desuperheating and subcooling zones shall be in accordance with ASTM A285/A285M, Grade C. Tubes shall be stainless steel in accordance with ASTM A688/A688M, Grade TP 304, stress relief annealed temper with the U-bends stress relieved after bending.

2.19 DEAERATING FEEDWATER HEATER

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NOTE: Economizer or preheater will be selected to be compatible with pollution control equipment being utilized.

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Deaerating feedwater heater shall be installed where indicated and shall be size and capacity indicated. Shell shall be [cast iron] [steel plate]. [Tray system for unit shall be [cast-iron] [corrosion-resistant steel.] Floats shall be of [copper] controlled overflow-trap] type. Heater shall be provided with [a pressure relief valve,] [thermometers,] [pressure gauge,] [and] [oil separator]. [A combination temperature-pressure recorder shall be installed for each feedwater heater.] [Steam pressure readings shall be taken from the shell, and the temperature bulb shall be so placed as to [indicate] [record] the temperature of the feedwater after it passes over the trays and sprays.] An alarm shall be provided to turn on a red pilot signal lamp and to sound a bell gong in the event that water level in the feedwater heater storage tank falls to 300 mm 12 inches above the bottom of the tank. The system shall be operated by an approved type of external electric float switch connected to the tank. The signal lamp and bell shall be mounted where directed. The deaerating feedwater heater shall have a capacity of [_____] pounds of water per hour at a discharge temperature of [_____] degrees F at the following inlet conditions:

	Pressure (kPa) (psig)	Temperature range (deg C) (deg F)	Flow rate (kg/hr) (lb/hr)
Condensate return	[_____]	[_____]	[_____]
High-pressure trap returns	[_____]	[_____]	[_____]
Makeup water	[_____]	[_____]	[_____]
Heating steam	[_____]	[_____]	[_____]

2.20 STEAM TRAPS

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NOTE: The design engineer, when designating steam-using equipment or special steam applications, will indicate the type of steam trap required in accordance with the following data:

a. Inverted Bucket Traps: This type of trap continuously vents air and carbon dioxide at steam temperature and is recommended for modulating loads. The bucket floats on steam to close the outlet and sinks into condensate to open the condensate outlet. Any trapped air is discharged first into the condensate return line and is followed by condensate discharge. This type of trap has the longest life on systems under modulated control. When large amounts of air are anticipated, an external thermostatic air vent should be installed on a line bypassing the trap to bleed air from the steam line and discharge it to the condensate return line. This system will give optimum performance at low steam pressures with maximum dependability. These traps will handle condensate from fan coil units where condensate must be lifted to return lines located above the equipment. They operate best at near full load conditions where loads do not vary over a wide range. Before operation, traps must be primed by filling them with water.

b. Vertical Open-Top Bucket Trap: Trap construction is more complex than inverted bucket type but is suitable for applications having wide variation of load and pressure, and is recommended for constant pressure systems. Bucket sinks into condensate when condensate reaches top of trap and the discharge port opens. After discharge, the bucket floats on incoming condensate keeping the discharge port closed.

c. Impact-Operated Traps: These traps depend on steam velocity to keep the disc closed. As steam velocity decreases, the disc lifts off the seat and allows flow of condensate. These traps allow some steam leakage and do not vent air at low pressure. They are not recommended for service lower than 70 kPa 10 psig or where back pressure may exceed 50 percent of inlet pressure. These traps are less expensive and have poor performance in the presence of dirt.

d. Thermostatic Traps: These traps are bellows-actuated and contraction of bellows at a few degrees below saturated steam pressure allows condensate air and noncondensable gases to be discharged. As steam reaches the bellows, the expansion of the bellows closes the discharge port. These traps can also be utilized to vent air from a

steam system and can be used in conjunction with an inverted bucket type steam trap previously described.

e. Float and Thermostatic Trap: These traps provide optimum performance on modulating systems at lowest first cost. Where steam pressures modulate down to zero, large amounts of air may be liberated. They are ideal for dripping ends of steam risers, heels of up-feed steam risers, bottoms of down-feed steam risers. These traps are also ideal for fan coil units and unit heaters.

f. Any trap selected must be sized for the expected condensate load with an applicable safety factor applied for the particular type of equipment serviced. Manufacturer's application manuals should be consulted to assist in sizing traps. Safety factors vary from 2:1 to 10:1. An average 3:1 safety factor value will cover most applications.

g. Service life between repairs or replacement of traps may be a determining factor in the choice of traps. One manufacturer of all types of traps offers the following experience record:

Type of Trap	Average Service Life Between Replacement or Repairs
Inverted bucket traps	42 months
Float and thermostatic traps	24 months
Thermostatic traps	24 months
Impact-operated traps	19 months

****

Steam traps shall be in accordance with ASTM F1139, type, style, and class as applicable.

2.20.1 Bucket Traps

Bucket traps shall be, either the inverted bucket type or the vertical bucket type with automatic air discharge. The traps shall be designed for a working pressure of 1.03 MPa 150 psig, but shall be in the correct pressure class to operate properly at the actual steam supply pressure indicated for the system. Valve and seat shall be constructed of stainless steel. All other interior parts shall be of corrosion-resistant metal and the traps may be sealed type with corrosion-resistant steel bodies. Traps shall discharge the condensate to the return line and shall be connected as indicated. A suitable strainer with blow-off valve shall be installed in the intake connection to each trap. Capacity of traps shall be not less than that indicated.

2.20.2 Impact-Operated Traps

Impact-operated traps, impulse-operated traps, or thermodynamic traps with

continuous discharge may be installed in lieu of bucket traps if applicable, subject to approval of the Contracting Officer.

2.20.3 Thermostatic Traps

Thermostatic traps designed for a steam working pressure suitable for the application may be furnished in lieu of the traps specified above if applicable. Thermostatic trap capacities shall be based on a pressure differential not in excess of the following:

Steam working pressure	Differential pressure
275-350 kPa40-50 psig	240 kPa35 psig
620-690 kPa90-100 psig	550 kPa80 psig

2.20.4 Float and Thermostatic Traps

Float and thermostatic traps shall be designed for a steam working pressure of 103 kPa 15 psig but shall operate with the supply pressure indicated for the system. The trap capacity shall be based on a pressure differential of 15 kPa 2 psi. The inlet to each trap shall be provided with a brass or stainless steel strainer either separately or as an integral part of the trap.

2.21 PRESSURE GAUGES

Pressure gauges shall be heavy-duty industrial type with phenolic case, solid front, rear blowout, threaded ring, shatterproof glass, and 13 mm 1/2 inch NPT bottom connection suitable for specified pressure or vacuum with minimum 114.3 mm 4-1/2 inch diameter dial, except as other-wise specified. Pressure gauges shall be installed on the low-pressure side of each pressure reducing valve, on the suction and discharge side of each pump, on inlets and outlets of heat exchangers, on the feedwater heater, and where shown or required for proper operation. Pressure gauge shall be installed on each boiler and shall have a [254.0 mm 10 inch dial] [304.8 mm 12 inch dial] face. Gauges shall be installed so as to be accessible and easily read from the operating floor. Gauges shall be equipped with integral or separate siphons, and pulsation dampeners and shall be connected by brass pipe and fittings with shutoff cocks. Where pressure reducing valves are used, upstream and downstream gauges shall be placed close to the pressure reducing assembly, but connected approximately 3 m 10 feet therefrom. The operating ranges of the gauges shall be approximately twice the normal operating pressure.

2.22 THERMOMETERS

Thermometers shall be bimetallic type with stainless steel case and stem, separable stem, separable thermowells, and temperature range suitable for the use encountered. Thermometers shall be installed in the feedwater heater storage and steam areas, boiler feed pump; in the main condensate return line before entering the surge tank; in the combustion air inlets and outlets of air preheaters, water inlets, and outlets of economizers; in the suction and discharge of boiler feed pumps; in air inlets to forced and induced draft fans; in the flue gas inlets and outlets of economizers and air preheaters; and elsewhere as indicated or specified. Thermometers shall have a universal joint and shall be easily read from the operating floor. Thermometers shall have 127.0 mm 5 inch scales except where 304.8

mm 12 inch scales are required for remote reading and plus or minus 1 percent accuracy.

2.23 WATER METER

****

NOTE: For boilers having less than 4,540 kg 10,000 lbs per hour steaming capacity, a mechanical type feedwater meter may be provided in accordance with this paragraph. Plants having metered zeolite softeners used exclusively for boiler makeup purposes will not require an additional cold water makeup water meter. Boilers over 4,540 kg 10,000 lbs per hour capacity will have indicating-recording meters and they shall be integrating type where indicated.

****

Water meter, including the three-valve bypass and connections, shall be provided in the cold water makeup line [and in each boiler feedwater line]. Water meters shall be disk type with reinforced disk for hot water above 65 degrees C 150 degrees F and rubber or synthetic polymer disk for cold water, and shall be constructed of bronze composition and cast-iron protected by noncorrosive coating. Moving parts subject to wear shall be easily removable. Meters shall conform to the requirements of AWWA C700.

2.24 CHEMICAL TREATMENT AND WATER SOFTENING EQUIPMENT

****

NOTE: Inapplicable type of chemical feeder will be deleted in accordance with the requirements of UFC 3-410-01 or UFC 3-410-02.

****

2.24.1 Chemical Feeder

A feeder unit shall be provided for each boiler. Chemical feeder shall be automatic proportioning, shot, or pump type. All appurtenances necessary for satisfactory operation shall be provided. Size and capacity of feeder shall be based upon local requirements and water analysis. Chemical feed pumps and tanks shall be furnished as a package with the pumps mounted on and piping connected to the tank. The pump cylinders, plungers, ball check valves, and check valve bodies shall be of corrosion-resistant materials suitable for the chemicals being pumped. Volumetric accuracy of the pumps shall be within one percent over the range indicated. Pump capacities shall be adjustable by positioning crank pin with micrometer setscrews. Stroke length scale shall be divided in percentage graduations engraved on scale. Cylinders shall be replaceable for increased or reduced pressure or capacity ranges. Drive motors shall be suitable for the electrical power available and shall have drip-proof enclosures. Tanks shall be made of polypropylene and mounted on legs. Tanks shall have filling and drain connections and gauge glass. Each tank shall be furnished with one pump, mounted and piped with black iron pipe and fittings, with suction strainer and stainless steel screen, and with 13 mm 1/2 inch relief valve with steel body and stainless steel trim. Each tank shall have hinged cover. Tank bottom shall be dished concave to a radius equal to the diameter of the tank. Units shall be for phosphate or caustic feed and sulfite feeding. Motor-driven agitator shall be provided. The pump shall be designed to feed the chemical solutions into

the boiler feedwater system.

2.24.2 Water Softening Equipment

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

A [single] [double] unit automatic water softener system shall be provided as indicated. The system shall be designed for a working pressure of [_____] Pa psig. The system shall be complete with raw and regenerate water distribution; under drain; inlet and outlet connection in upper and lower header respectively; resin removal connecting pipe legs; control valve for service, backwash, regenerate, and rinse; water meters, pressure gauges, brine storage, and measuring tank and controls for automatic operation. Brine tank shall be either hot-dipped galvanized after fabrication or polypropylene. Brine piping shall be either all copper pipe and fittings or Schedule 80 PVC. The equipment shall have a total capacity between regenerations of not less than [_____] liters gallons of water of [_____] grams grains hardness when operating at a sustained softening rate of [_____] L/second gpm. The system shall be based on the data below. Test sets shall be provided for pH comparator for the range [_____] to [_____] sulfite comparator, and phosphate comparator.

2.24.2.1 Water Analysis

The source of the raw water is [_____]. The analysis of the water is approximately as follows:

Constituents*	
Sodium as (Na)	[_____] ppm
Silica as (SiO(2))	[_____] ppm
Calcium as (Ca)	[_____] ppm
Magnesium as (Mg)	[_____] ppm
Iron and aluminum oxides as (Fe(2)O(3)), (Al(2)O(3))	[_____] ppm
Bicarbonates as (HCO(3))	[_____] ppm
Carbonates as (CO(3))	[_____] ppm
Hydroxides as (OH)	[_____] ppm
Sulphates as (SO(4))	[_____] ppm
Chlorides as (Cl)	[_____] ppm

Constituents*	
Phosphates as (PO(4))	[_____] ppm
Carbon Dioxide (free CO(2))	[_____] ppm
Total hardness as (CaCO(3))	[_____] ppm
Total solids in solution	[_____] ppm
Volatile and organic matter	[_____] ppm
Suspended matter	[_____] ppm
Free acid	[_____] ppm
Color	[_____]
pH	[_____]
*Numbers in parentheses are subscripts.	

2.24.2.2 Zeolite

Zeolite shall be the high capacity polystyrene base sulphonic synthetic type. Not less than [_____] cubic meter feet of zeolite shall be provided with each reactor tank.

2.24.2.3 Reactor Tank

Reactor tank sizes shall be based on allowing a freeboard above the zeolite bed of not less than 50 percent of the zeolite bed depth, and a maximum flow rate of 11.3 mL/square meters per second one gallon/square foot per minute for each 111 mm 4-3/8 inches of zeolite bed depth.

2.24.2.4 Softening System

The softening system shall be complete with all piping, control, and power wiring. A complete initial charge of rock salt shall be installed in the brine tank as recommended by the softener manufacturer.

2.24.2.5 Water Test Kit

A kit complete with test containers, reagents, and instructions for testing the raw and effluent water shall be provided in a strong carrying case.

2.24.2.6 Treated Water Storage Tank

Treated water storage tank shall be fabricated from steel plates not less than 4.7625 mm 0.1875 inch thick for shell and heads, and shall be constructed in accordance with ASME BPVC SEC VIII D1 for unfired pressure vessels for a design working pressure of 517 kPa 75 psig. Heads shall be dished concave to pressure to a radius equal to the diameter of the tank. The tank shall be provided with the connections indicated, an 203.2 mm 8 inch copper ball float, level-operated control valve, valve bypass and

accessories, and a protected gauge glass. The tank shall be the diameter shown and shall have a capacity of not less than [_____] liters gallons. The tank shall be hydrostatically tested at the factory at not less than 690 kPa 100 psig.

2.25 BUILDING HEATING EQUIPMENT

2.25.1 Unit Heaters

2.25.1.1 General

The manufacturer of the unit heaters shall not select individual heaters with a capacity in excess of 125 percent of the value specified for the heater. Orifice plates shall be provided to reduce the joule Btu output where required. The noise level of each unit heater shall be appropriate for the space in which the heater is installed. The sound power level [_____] decibels reference shall not exceed the following values in each octave band at the midfrequency, cycles per second:

Octave Bands	3	4	5	6	7
Midfrequency (in Hz)	250	500	1000	2000	4000
	Sound Power Level				
Office Space	54	50	47	45	43
Conference Rooms, Communication Facilities	51	46	45	42	38
Shops, Factories	69	62	61	58	57

The sound power level data for these units shall be based on tests conducted in accordance with ASA S1.13.

2.25.1.2 Propeller Type Unit Heater

Heater shall be designed for suspension and arranged for horizontal or vertical discharge of air as indicated. The casings shall be not lighter than 0.912 mm 20 gauge steel. Suitable stationary or rotating air deflectors shall be provided to assure proper air and heat penetration at floor level. Suspension from heating pipes will not be permitted. Vertical discharge heaters shall operate at speeds not in excess of 1200 rpm, except that units with 53 Megajoules 50,000 Btu output capacity or less may operate at speeds up to 1,800 rpm. Horizontal discharge unit heaters shall have discharge or face velocities not greater than the following:

Unit Capacity	Face Velocity
Up to 0.472 cu m/second 1,000 cuf/minute	4.0 m per second800 feet per minute
0.472 to 1.4 cu m/second1.001 to 3,000 cu f/minute	4.6 m per second900 feet per minute

Unit Capacity	Face Velocity
1.4 and over cu m/second3.001 and over cu f/minute	5.1 m per second1,000 feet per minute

2.25.1.3 Cabinet Unit Heaters

Heaters shall be centrifugal fan type arranged for floor or ceiling mounting as indicated. The heating elements and fans shall be housed in steel cabinets with angle iron frames. The cabinets shall be of not lighter than 0.912 mm 20 gauge steel. Each unit heater fan discharge shall be provided with an approved adjustment for air diffusion and distribution. The fans shall be mounted on a common shaft with one fan to each air outlet. The fan shaft shall be equipped with self-aligning ball or roller bearings accessible for lubrication. The fan shaft shall be either directly connected to the driving motor or indirectly connected by adjustable V-belt drive rated at 150 percent of motor capacity. All exposed moving parts shall have guards. All fans in any one unit heater shall be the same size.

2.25.1.4 Heating Elements

Heating coils shall be copper, and radiating fins may be copper, aluminum, or suitable ferrous alloy. The heating elements shall be free to expand or contract without developing leaks and shall be properly pitched for drainage. The elements shall be tested under a hydrostatic pressure of 1.4 MPa 200 psi and a certified report of the test shall be submitted to the Contracting Officer.

2.25.1.5 Manual Selection Switches

Motors shall be provided with manual selection switches for [on, off, and automatic] [on-off] operation and shall be equipped with thermal-overload protection.

2.25.1.6 Automatic Operation

2.25.1.6.1 Thermostatic Control by Fan Regulation

The unit heaters shall be controlled automatically by thermostats located where indicated. The thermostats shall be adjustable and fitted with thermometers. Each thermostat shall operate on not more than a 2 degrees C 3 degrees F differential over a temperature range of approximately 13 to 24 degrees C 55 to 75 degrees F. The thermostat shall start or stop the respective unit heater fan motor when the room temperature falls below or rises above the thermostat set point. Summer-winter switches for fan operation shall be provided adjacent to the thermostat for each unit heater.

2.25.1.6.2 Thermostatic Control by Steam Valve Regulation

Cabinet type unit heaters shall be controlled automatically by proportioning type thermostats and modulating steam valves located where indicated. On-Off switches for fan operation shall be provided adjacent to the thermostat for each fan unit. The thermostats and valves shall maintain the desired room temperature within 1 degree C 2 degrees F of the thermostat set point by regulating the steam supplied to the coil.

2.25.2 Radiator and Convector

Each [radiator] [convector] unit shall be provided with a top supply connection with a control valve and a bottom return connection with a thermostatic trap. Each unit shall be tested hydrostatically at the factory and proved tight at a pressure of not less than 690 kPa 100 pounds. Extended surface tube-type radiators shall consist of suitable metal fins permanently bonded to copper or steel pipe cores threaded at each end for connecting to external piping. Radiator capacities shall be determined in accordance with the HYI-005 Rating Code. Radiators shall be equipped with [expanded metal cover grilles fabricated from steel sheets not lighter than 1.519 mm 16 gauge, secured either directly to radiators or to independent brackets] [solid front, slotted, horizontal top grilles fabricated from steel sheets not lighter than 1.214 mm 0.0478 inch thick, secured either directly to radiators or to independent brackets] [solid front, slotted, sloping, top cover grilles fabricated from steel sheets not lighter than 1.214 mm 0.0478 inch thick independently secured to masonry with brackets]. [Nonferrous convectors shall be tested hydrostatically at the factory and proved tight under a pressure of not less than 585 kPa 85 psig.]

2.26 AIR COMPRESSOR UNITS

Air compressor shall conform to ASME PTC 10, except as specified otherwise. Compressor speed shall not exceed 900 rpm. Motor speed shall not exceed 1750 rpm.

2.26.1 Service Air Compressors

The service air requirements shall be as indicated with receivers sized as indicated. The units shall be suitable for heavy-duty service (soot blowing). The compressors shall be simplex type, single-stage, double-acting, with water-jacketed cylinder; fitted with intake and discharge valves of the lightweight feather, disc, or plate type; and shall be provided with necessary controls, water-cooled aftercooler, moisture separator, drive, receiver, relief valves, and cooling water controls as indicated or required. The compressor air intake shall be provided with a low drop-type air suction filter/silencer suitable for outdoor installation. The aftercooler shall be the shell-and-tube type designed for air flow through the tubes with steel shell internal baffle plates and Admiralty metal tubes expanded into Muntz metal tube sheets. The moisture separator shall be provided with an automatic water discharge trap and level gauge. The air receiver shall be vertical type, constructed in accordance ASME BPVC SEC VIII D1 for unfired pressure vessels for 1.4 MPa 200 psi working pressure, and shall be equipped with flanged inlet and outlet connections, valved drain connection, 152 mm 6 inch dial pressure gauge, pop safety valves, and regulator connections. Cooling water controls for regulating compressor cylinder water temperature and aftercooler water temperature shall be thermostatic valve type and shall be installed with a three-valve bypass in the water outlet lines ahead of open sight drain funnels. The compressor shall be equipped with adjustable, pressure-type unloader controls suitable for continuous compressor operation.

2.26.2 Instrument Air Compressors

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NOTE: The designer should determine if two redundant full-size instrument air compressors will be required as loss of air will cause unit shutdown

unless other provisions are made, such as crossties to the soot blower/service air system. Delete paragraph if not required.

****

An electric motor-driven oil-free automatic air compressor unit and a refrigerating drying unit shall be provided. The air compressor shall be capable of delivering, at a pressure of [_____] Pa psig, not less than 0.00472 standard cubic meters/second 10 scfm dry air at an atmospheric dew point of -23 degrees C -10 degrees F with entering air at 35 degrees C 95 degrees F, saturated. The air compressor unit shall be sized to run not more than 60 percent of the time when all controls are in service. The air compressor unit shall be complete with all necessary accessories including automatic pressure control equipment, relief valves, check valves, air filters, moisture traps, and a receiver with ample capacity for emergency operation of the controls for 15 minutes after compressor shutdown. The receiver shall be of vertical construction, in accordance, ASME BPVC SEC VIII D1 with relief valve and drain fittings. The air dryer shall be a self-contained, refrigerated type, complete with refrigeration compressor, heat exchanger, automatic controls, and moisture removal trap, or a regenerative desiccant type dryer, as required. The refrigeration unit shall be the hermetically-sealed type capable of continuous operation at maximum load conditions.

2.27 PIPING

Unless otherwise specified herein, pipe and fittings shall conform to ASME B31.1.

2.27.1 Pipe

Pipe material shall be as specified in TABLE I.

2.27.2 Fittings

Pipe fittings shall be as specified in TABLE II.

2.27.3 Nipples

Nipples shall conform to ASTM A733, Type I or II, as required to match adjacent piping.

2.27.4 Unions

Unions shall conform to ASME B16.39, type as required to match adjacent piping.

2.27.5 Pipe Threads

Pipe threads shall conform to ASME B1.20.2MASME B1.20.1, right- or left-hand tapered thread as required.

2.27.6 Expansion Joints

2.27.6.1 Guided, Slip-Tube Type Expansion Joints

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NOTE: Wherever possible, provision for expansion of steam supply and return pipes will be made by

changes in the direction of the run of the pipe or by field-fabricated expansion bends. If expansion joints are not required, applicable paragraphs will be deleted. Where space limitations prevent such provisions for expansion, expansion joints will be installed.
****

Guided, slip-tube expansion joints shall conform to EJMA Stds and ASME B31.1. End connections shall be flanged. Anchor bases or support bases shall be provided as indicated or required. The joints shall be designed for a steam working pressure not less than [_____] Pa psig. Joints shall provide for either single or double slip of the connected pipes, as indicated, and for not less than the traverse indicated. [Service outlets shall be provided where indicated or required.]

2.27.6.2 Bellows Type Expansion Joints

Bellows type joints shall be flexible, guided expansion joints conforming to EJMA Stds and ASME B31.1. The expansion element shall be stainless steel. Guiding of piping on both sides of expansion joint shall be in accordance with the published recommendations of the manufacturer of the expansion joint. The joints shall be designed for the working temperature and pressure suitable for the application, but design pressure shall not be less than 1.03 MPa 150 psig.

2.27.6.3 Flexible Ball Type Expansion Joints

Flexible ball joints shall be [stainless steel] [malleable-iron] [ductile iron] [carbon steel] [bronze] or other alloys as appropriate for the service intended. The joints may be threaded, flanged, or welded end, as required, and shall be capable of absorbing the normal operating axial, lateral, or angular movements or combination thereof. The ball-type joint shall be designed and constructed in accordance with ASME B31.1 and EJMA Stds, where applicable. Flanges shall conform to the diameter and drilling provisions of ASME B16.5. Molded gaskets furnished shall be suitable for the service intended.

2.27.7 Valves

Valves shall be installed at indicated locations, where specified, and where required for proper functioning and servicing of the system. Valves shall be of the pressure class shown. Motor-operated valves shall be capable of closing speeds of 2.5 to 5.1 mm/sec 6 to 12 inches/minute. Motor operators shall be equipped with position indicators, valve stem protectors above the motor operating units, and auxiliary handwheels for manual operation of the valves in the event of power failure. Motors shall be suitable for operation on the electrical current characteristics indicated.

2.27.7.1 Check Valves

****
NOTE: The designer shall indicate the type of valves, vertical lift or horizontal, on the drawings.
****

a. Valves for 125 pound class steel piping shall conform to the following:

(1) Sizes 65 mm 2-1/2 inches and less, bronze: MSS SP-80, Type 3 or 4, Class 125.

(2) Sizes 80 mm 3 inches through 600 mm 24 inches, cast-iron: MSS SP-71, Type III or IV, Class 125.

b. Valves for 150 pound class steel piping shall conform to the following:

(1) Sizes 65 mm 2-1/2 inches and less, bronze: MSS SP-80, Class 150 minimum.

(2) Sizes 80 mm 3 inches through 600 mm 24 inches, steel: ASME B16.34, Class 150 minimum, flanged ends, swing disc.

c. Valves for system operating pressure greater than 1.4 MPa 200 psi shall be swing check or lift check valves having a steel body and shall be suitable for specified operating pressure, but not less than Class 300 300 pound class. Valves 40 mm 1-1/2 inches and smaller shall be cast or forged steel with socket welded ends. Valves 50 mm 2 inch and larger shall be steel with butt welded ends. Check valves shall have renewable composition discs or shall have metallic discs of the regrindable type which permits regrinding without removing valve from the line.

2.27.7.2 Gate Valves

Gate valves used as shutoff valves in the boiler leads to the steam headers, and elsewhere as indicated, shall be of the chain-operated type, with enough chain for easy operation from the operating floor or walkway. Gate valves 200 mm 8 inches and larger used on high-pressure steam lines, and elsewhere as indicated shall be provided with a globe valve bypass.

a. Valves for 125 pound class steel piping shall conform to the following:

(1) Sizes 65 mm 2-1/2 inches and less, bronze: MSS SP-80, Type 1 or 2, Class 125.

(2) Sizes 80 mm 3 inches through 1200 mm 48 inches, cast-iron: MSS SP-70, Type I, Class 125, Design OT or OF (OS&Y), bronze trim.

b. Valves for 150 pound class steel piping shall conform to the following:

(1) Sizes 65 mm 2-1/2 inches and less, bronze: MSS SP-80, Type 1 or 2, Class 150 minimum.

(2) Sizes 80 mm 3 inches through 600 mm 24 inches, steel: ASME B16.34, Class 150 minimum, flanged ends.

c. Valves for system operating pressure greater than 1.4 MPa 200 psi shall be split wedge disc type, outside screw and yoke, steel and shall be suitable for specified operating steam pressure, but not less than Class 300 300 pound class. Valves 50 mm 2 inch and smaller shall be forged steel with socket welded ends. Valves 65 mm 2-1/2 inches and larger shall be steel and shall have butt welded ends.

2.27.7.3 Globe Valves and Angle Valves

Globe type valves shall have outside screw and yoke with bolted bonnets, stainless steel trim, and flat seats, but shall not be the reversed cup

type. The stuffing boxes shall be large and deep. Valves shall be installed with the stem horizontal or above.

a. Valves for 125 pound class steel piping shall conform to the following:

(1) Sizes 65 mm 2-1/2 inches and less, bronze: MSS SP-80, Type 1, 2, or 3, Class 125.

(2) Sizes 80 mm 3 inches through 300 mm 12 inches, cast-iron: MSS SP-85, Type III and Type IV, Class 125.

b. Valves for 150 pound class steel piping shall conform to the following:

(1) Sizes 65 mm 2-1/2 inches and less, bronze: MSS SP-80, Type 1, 2, or 3, Class 150 minimum.

(2) Sizes 80 mm 3 inches through 600 mm 24 inches, steel: ASME B16.34, Class 150 minimum, flanged ends.

c. Valves for system operating pressure greater than 1.4 MPa 200 psi shall be suitable for specified operating conditions, but not less than 300 pound class. Valves 50 mm 2 inch and smaller shall be forged steel with socket welded ends. Valves 65 mm 2-1/2 inches and larger shall be steel and shall have butt welded ends. Valves shall have renewable flat metal seats.

2.27.7.4 Steam Pressure Reducing Valves

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NOTE: Single-seated valves should be used when a dead-end shutoff of the steam is required. When a thermostatically-controlled valve is installed after and near the reducing valve in a manner to cut off the passage of steam, the single-seated valve should be used. Double-seated valves may be used where the low (reduced) pressure lines will condense enough steam to offset normal leakage through the valve. Under conditions of widely varying initial pressure, double-seated valves usually give closer control of reduced pressure.

****

Reducing valves designed for the working pressure shown, but not for less than 1.4 MPa 200 psig, shall be provided wherever indicated or required. Each reducing valve shall be adjusted to maintain the desired terminal pressure, regardless of fluctuations in the initial pressure. The valves shall be [single seated] [doubled seated], spring-loaded, quiet in operation, and shall not stick internally. Pilot-operated valves or other controllers using steam or compressed air for operating medium shall be provided. Valves 65 mm 2-1/2 inches and larger shall be cast steel, cast-iron, or semisteel as required for the steam pressure. Valves 50 mm 2 inches and smaller shall be bronze. Valve trim for iron body valves shall be stainless steel, nickel copper, or other approved corrosion-resisting material. All parts subject to wear shall be readily renewable. Valves shall have seats and plugs faced with a cobalt-tungsten carbide mixture, or made of heat-treated stainless steel or a high chromium steel designed to resist erosion. Seat and plug facing shall have a Brinell hardness of not less than 450. Each valve shall be installed with a strainer, a three-valve bypass, and a safety relief valve

as indicated. Where pressure reducing valves are used for reducing the steam pressure to the deaerating heater, the valves shall be the single seated type. The sensing lines shall be connected to the steam space in the deaerator or at least 3 m 10 feet downstream of the pressure reducing valve.

2.27.7.5 Thermostatic Regulating Valves

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NOTE: If a hot water generator is not installed, this subparagraph will be deleted.
****

Valves of the self-contained type to control water temperature within the domestic hot water generator by regulating the steam supplied to the heating coil shall be installed in the steam supply line to each generator. Thermostatic regulating valves shall be designed for a steam working pressure of 1.4 MPa 200 psig and shall operate at the pressure shown. The valves shall be adjustable within an operating range of approximately 38 to 71 degrees C 100 to 160 degrees F and shall maintain the desired water temperature within plus or minus 3 degrees C 5 degrees F.

2.27.7.6 Back Pressure Relief Valves

Valves shall have cast-iron or steel bodies and shall be equipped with corrosion-resistant trim and valve seats. The valves shall be properly guided and shall be positive closing to prevent leakage. Adjustment of the desired back pressure shall cover a range between 34 to 103 kPa 5 to 15 psig. The adjustment shall be effected externally, and any shafts extending through the valve body shall be provided with adjustable stuffing boxes having renewable packing.

2.27.7.7 Boiler Automatic Feedwater Recirculating Control Valve

****
NOTE: If automatic recirculation valve is not utilized, delete this paragraph.
****

Valve shall be the self-contained self-powered type. The unit shall automatically program the recirculation flow when required and assume all functions for prevention of the backflow of the main feedwater flow, for detection of low flow, for cycling of the control valve, and for the pressure reduction for liquid delivery to the low-pressure feedwater heater. The valve assembly shall be flanged type with flanged spools provided in both the main line and recirculation line for ease of disassembly.

2.27.8 Exhaust Heads

Exhaust heads for the discharge of steam to atmosphere shall be one-piece plate steel, semisteel, or cast-iron construction with internal baffle arrangement for the removal of entrained condensate and oil, and with provision for drain connection. Flow area through unit shall be larger than connecting pipe.

2.27.9 Strainers

The strainer body connections shall be of the same size as the pipelines

in which the connections are installed. The strainer bodies shall be heavy and durable cast steel [or gray cast-iron]. The bodies shall have arrows clearly cast on the sides to indicate the direction of flow. Each strainer shall be equipped with an easily removable cover and sediment basket. The basket shall be not less than 0.63 mm 0.025 inch thick corrosion-resistant steel [or sheet brass] with enough small perforations to provide a net free area through the basket of at least 3.30 times that of the diameter of the entering pipe.

2.27.10 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts and supports shall conform to MSS SP-58, except as modified herein:

a. Types 5, 12, and 32 shall not be used.

b. Type 3 shall not be used on insulated pipe which has a vapor barrier. Type 3 may be used on insulated pipe that does not have a vapor barrier if clamped directly to the pipe and if the clamp bottom does not extend through the insulation and the top clamp attachment does not contact the insulation during pipe movement.

c. Type 18 inserts shall be secured to concrete forms before concrete is placed. Continuous inserts which allow more adjustment may be used if they otherwise meet the requirements for Type 18 inserts.

d. Type 19 and 23 C-clamps shall be torqued in accordance with MSS SP-58 and have both locknuts and retaining devices furnished by the manufacturer. Field-fabricated C-clamp bodies or retaining devices are not acceptable.

e. Type 20 attachments used on angles and channels shall be furnished with an added malleable-iron heel plate or adaptor.

f. Type 24 may be used only on trapeze hanger systems or on fabricated frames.

g. Where Type 39 saddle or Type 40 shield is permitted for a particular pipe attachment application, the Type 39 saddle shall be used on all pipe 100 mm 4 inches and larger.

h. Horizontal pipe supports shall be spaced as specified in MSS SP-58 and a support shall be installed not over 300 mm 1 foot from the pipe fitting joint at each change in direction of the piping. Pipe supports shall be spaced not over 1.5 m 5 feet apart at valves. In the support of multiple pipe runs on a common base member, a clip or clamp shall be used where each pipe crosses the base support member. Spacing of the base support members shall not exceed the hanger and support spacing required for any of the individual pipes in the multiple pipe run. The clips or clamps shall be rigidly connected to the common base member. A clearance of 3 mm 1/8 inch shall be provided between the pipe and clip or clamp for all piping which may be subjected to thermal expansion.

i. Vertical pipe shall be supported at each floor, except at slab-on-grade, and at intervals of not more than 4.5 m 15 feet, not more than 2.4 m 8 feet from end of risers, and at vent terminations.

j. Type 35 guides using steel, reinforced polytetrafluoroethylene (PTFE)

or graphite slides shall be provided, where required, to allow longitudinal pipe movement. Lateral restraints shall be provided as required. Slide materials shall be suitable for the system operating temperatures, atmospheric conditions, and bearing loads encountered.

(1) Where steel slides do not require provisions for restraint of lateral movement, an alternate guide method may be used. On piping 100 mm 4 inches and larger, a Type 39 saddle may be welded to the pipe and freely rest on a steel plate. On piping under 100 mm 4 inches, a Type 40 protection shield may be attached to the pipe or insulation and freely rest on a steel slide plate.

(2) Where there are high system temperatures and welding to piping is not desirable, then the Type 35 guide shall include a pipe cradle, welded to the guide structure and strapped securely to the pipe. The pipe shall be separated from the slide material by at least 100 mm 4 inches, or by an amount adequate for the insulation, whichever is greater.

k. Pipe hangers on horizontal insulated pipes, except for Type 3, shall be the size of the outside diameter of the insulation.

l. Piping in trenches shall be supported as indicated.

2.28 INSULATION

Shop and field applied insulation shall be as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.29 TOOLS

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

2.29.1 Tube Brush

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NOTE: Applies to firetube boilers.
****

Tube brush, with steel bristles and jointed handle of sufficient length to clean full length of firetubes, shall be provided.

2.29.2 Smoke Pipe Cleaner

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

2.29.3 Firing Tools

Firing tools including hoe, poker, and slice bar shall be provided for each boiler.

2.29.4 Wrenches and Gaskets

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

2.30 COAL HANDLING EQUIPMENT

2.30.1 Screw Conveyor

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NOTE: Where motor starters for mechanical equipment are provided in motor control centers, delete the reference to motor starters.
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Screw conveyor for the lateral distribution of coal shall consist of steel screw conveyor with capacity of not less than [_____] cubic meters/second cubic feet/hour when handling coal of the specified maximum lump size. Maximum capacity of the conveyor shall be based on the screws carrying not more than 30 percent of their cross section (except feeder conveyors), and the maximum speed of conveyor shall be 60 rpm. Conveyor and housing shall be assembled in sections. The sectional flights shall be mounted on steel pipe and connected by coupling shafts. A feeder conveyor may be installed to assume the proper distribution of the load. Both the feeder screw and the extended screw shall have their flights mounted on the same pipe. The conveyor shall be provided with sectional supporting hanger bearings of the babbitted type. Conveyor length between bearings shall not exceed 3.7 m 12 feet. Trough ends shall be fabricated cast-iron type with feet and fitted with babbitted bearings. The drive shall be at the discharge end of the conveyor and shall consist of an electric gear motor and chain drive. The chain drive from the motor to the reducer shall be enclosed in an oil-tight casing. Thrust in either direction shall be absorbed by the thrust bearings. The motor may be mounted on top of the trough. The trough conveyor housing shall be not less than 4.8 mm 3/16 inch steel with a 1.897 mm 14 gauge steel cover and shall be dust-proof. Discharge spout and coal gate shall be furnished as indicated. An approved type of supporting saddle shall be provided. Supports shall be spaced at not more than 3 m 10 foot intervals. Motor enclosure shall be [totally enclosed, nonventilated] [totally enclosed, fan-cooled type suitable for installation in a Class II, Division 1, Group F hazardous location in conformance with NFPA 70]. [Motor starter shall be [manual] [[magnetic] [across-the-line] [reduced voltage start]] type with [weather-resistant] [dust-tight] [explosion-proof] enclosure.] Dust controlling covers and inlet and discharge enclosures shall be provided for each conveyor.

2.30.2 Belt Conveyor

Belt conveyor shall be of the trough type, as shown. Maximum incline of the belt conveyor shall not exceed 15 degrees. The conveyor support frame shall have sufficient rigidity to maintain belt alignment, at least 75 mm 3 inches clearance to prevent damage to the edge of the belt on its return run, and adjustments for aligning shafts. Decking to protect the return belt from coal sifting and to provide lateral stiffness shall be placed on top of the stringers. Idlers shall be accurately made to provide a rigid framework that will maintain permanent alignment of well balanced, smooth-running, easy turning idler rolls. All idlers and return rolls shall be CEMA Belt Book, Series C5. Pressure lubrication shall be

provided to ball or roller bearings. Idlers shall be 20-degree or 35-degree three-roll type spaced on 1.2 m 4 foot centers, except under loading points and skirts. Return idlers shall be spaced on 3 m 10 foot centers. The belting shall be Grade 2 as defined in RMA IP-1. The belting shall have field-vulcanized splices. Pulleys shall be designed in accordance with CEMA B105.1, shall be heavy welded steel, true to diameter and accurately bored, key seated and tightly fitted to the shafts. Pulley face width for belts 1067 mm 42-inches wide and smaller, that are 150 m 500 feet or more in length, shall be belt width plus 100 mm 4 inches; less than 150 m 500 feet in length, shall be belt width plus 75 mm 3 inches. Pulley face width for belts 1.2 m 48 inches and larger shall be belt width plus 150 mm 6 inches. Drive pulleys shall be provided with 19 mm 3/4 inch thick vulcanized and grooved lagging. Snub pulleys shall be provided with 9.5 mm 3/8 inch vulcanized smooth lagging. All conveyor pulley shaft assemblies shall be supported by two heavy-duty antifriction bearings having a minimum life expectancy of 50,000 hours for 90 percent of bearings in accordance with ABMA 11 for roller bearings. The pulley diameter shall be sufficiently large to meet the requirements of the duck weight and ply of the belt to permit flexing of the belt around the pulley circumference without damaging the belt or shortening the belt life. The conveyor shall be driven by a [totally enclosed, nonventilated type] [totally enclosed, fan-cooled type] [totally enclosed, fan-cooled type suitable for installation in Class II, Division 1, Group F hazardous location in conformance with NFPA 70] electric motor connected to a drive-shaft-mounted speed reducer unit by a [roller chain drive] [V-belt drive] [flexible coupling]. [The motor starter shall be [manual] [[magnetic] [across-the-line] [reduced voltage start]] type with [general-purpose] [weather-resistant] [watertight] [dust-tight] [explosion-proof] enclosure.] All belt conveyors shall be provided with belt misalignment switches, emergency stop pull cords and pull switches, galvanized expanded metal shields over tail pulley, zero speed switches, loading skirts, plugged chute switches, walkways, supports, belt take-ups, belt cleaners, skirt boards, and pulley scrapers. Dust controlling covers and inlet and discharge enclosures shall be provided for each conveyor.

2.30.3 Flight Conveyor

[Scraper] [Shoe-suspended] flight conveyor arranged generally as shown and of the single-strand type shall have capacity not less than [_____] metric tons/hour tons/hour when handling coal with approximate weight of 800 kg/cubic meter 50 pcf and with maximum lump size of [_____] mm inches diameter. Capacity shall be based on a maximum speed of 0.508 m/sec 100 fpm with conveyor operating up a [_____] degree incline. Chain shall be drop-forged steel type with flights made of either steel or malleable-iron, spaced at least three times the largest lump size. Foot shaft shall have protected screw take-up with adjustment of not less than 300 mm 12 inches. Trough shall be made of 4.8 mm 3/16 inch steel plate, minimum. All sliding surfaces in contact with the chain or flights shall be lined with 19 mm 3/4 inch thick, removable, ultra high molecular weight polyethylene liners. Both sides of trough shall be provided with a warning sign "DANGER - DO NOT WELD - FLAMMABLE PLASTIC LINER." Signs shall be visible on each floor level and at frequent intervals. Conveyor shall be provided with discharge openings as indicated, each of which shall be provided with rack-and-pinion-operated gates with handwheels. Motor shall drive conveyor through a speed reduction unit which is either direct-connected or roller-chain-connected to the drive shaft. Motor shall be [totally enclosed, nonventilated type] [totally enclosed, fan-cooled type] [totally enclosed, fan-cooled type suitable for installation in a Class II, Division 1, Group F hazardous location in

accordance with NFPA 70]. [Motor starter shall be [manual] [[magnetic] [across-the-line] [reduced voltage start]] type with [general-purpose] [weather-resistant] [water-tight] [dust-tight] [explosion-proof] enclosure.] Conveyor frame shall be constructed essentially as indicated, with additional bracing as required for rigidity. Dust controlling covers and inlet and discharge enclosures shall be provided for each conveyor.

2.30.4 Bucket Elevators

Vertical bucket elevators shall be furnished dust tight, complete with continuous chain and attached buckets, upper and lower sprockets, gears, shafts, bearings, casing with flanged connections including top hood and discharge spout, bottom boot, access doors, electric motor drive, and all accessories. Bucket elevators shall be [vertical spaced centrifugal discharge] [positive discharge] [continuous bucket type]. The capacity of the elevator shall be not less than [_____] metric tons/hour tons/hour when handling coal weighing approximately 800 kg/cubic meter 50 pcf. Linear velocity shall be as indicated below:

Type of Bucket Elevator	Linear Velocity (meters per second) (fpm)
Centrifugal discharge	1.1-1.6225-305
Continuous bucket	0.508-0.686100-135
Positive discharge	0.610 120 Max

The head shaft and foot shaft shall be constructed of cold-rolled steel with the shaft diameters in accordance with manufacturers' standards. Both shafts shall be mounted in roller bearings with forced-type lubricating fittings. Foot shaft shall have screw take-up with adjustment of not less than 225 mm 9 inches. An automatic backstop shall be installed on the head shaft to prevent any backward motion of the chain. Boot plates [, loading legs of continuous bucket elevator,] and bottom plate of stub discharge chute shall be 4.8 mm 3/16 inch thick, minimum. All other flat casing members shall be 2.657 mm 12 gauge steel thick, minimum. Corner angles and stiffeners shall be provided to make the elevator self-supporting. In addition, the elevator shall be tied to the adjoining structure at close enough spacing to increase the rigidity of the elevator. The boot section shall be provided with clean-out doors, as well as front and back removable panels. An inspection door large enough to remove a bucket from either run of the chain shall be provided in the intermediate section at operating level. The elevator shall be driven by an electric motor installed in a suitable housing at the top of the flight. Motors shall be [totally enclosed, nonventilated] [totally enclosed, fan-cooled type] [totally enclosed, fan-cooled type suitable for installation in a Class II, Division 1, Group F hazardous location in accordance with NFPA 70]. [Motor starter shall be [manual] [[magnetic] [across-the-line] [reduced voltage start]] type with [general-purpose] [weather resistant] [water-tight] [dust-tight] [explosion-proof] enclosure.] A platform shall be installed adjacent to the motor for servicing the motor and equipment mounted in the hood. Access to the platform shall be by an approved type of safety ladder. Controls for the operation of the elevator shall be located as indicated. Dust control covers and inlet and discharge enclosures shall be provided for each conveyor.

2.30.5 Vibrating Conveyor

Vibrating conveyor shall be the electric-motor driven mechanical vibrating type with a capacity of [_____] metric tons/hour tons/hour when handling coal weighing approximately 800 kg/cubic meter 50 pcf and with maximum lump size of [_____] mm inches in diameter. Conveyor shall have a conveying length as shown. The conveyor trough shall be fabricated of [_____] mm gauge steel, [_____] mm inches in width and [_____] mm inches deep [and provided with dust-tight cover]. Conveyor pans of 9.5 mm 3/8 inch thick, Type 304L solid stainless steel plate shall be provided. The trough shall be mounted on vibrator bars, torsion bars, or coil springs attached to yoker legs of rigid cross brace construction and fabricated of corrosion-resistant material with hardened steel encased rubber bushings at articulation points. The base shall be fabricated of steel channels or angles bolted directly to [building support] [concrete foundations]. The drive shall be through an eccentric shaft supported by a double row of self-aligning ball-or roller-bearing pillow blocks. Positive action motion shall be imparted to the trough by a cast steel connecting rod attached to the trough by rubber-bushed wristpin and securely locked by taper lock bushings. The conveyor shall be driven by a [totally enclosed, nonventilated type] [totally enclosed, fan-cooled type suitable for installation in Class II, Division 1, Group F hazardous location in accordance with NFPA 70] electric motor connected to the eccentric shaft by V-belt drive. [The motor starter shall be [manual] [[magnetic] [across-the-line] [reduced voltage start]] type with [general-purpose] [weather-resistant] [water-tight] [dust-tight] [explosion-proof] enclosure.]

2.30.6 Gravimetric Weigh Feeder

The weigh feeder shall be a metering belt type device designed to operate at a variable rate ranging from 10 percent of maximum capacity to [_____] metric tons/hour tons/hour. Flow rate shall be automatic. A silicon-controlled, rectifier dc drive shall automatically adjust the belt speed to maintain the rate of material flow, as set on the controller. The weigh feeders shall meet or exceed the requirements of NIST HB 44 [Southern] [Eastern] [Western] Weighing and Inspection Bureau. They shall have an accuracy of 1/2 of 1 percent of flow rates over their total variable rated capacity. The feeder shall be provided with a flexible boot for connecting the gate to the feeder inlet chute, which in turn shall be flared to produce a feed opening tapering from [_____] wide to [_____] wide with the direction of flow of material. The belts for feeders shall meet RMA IP-1 requirements, conforming to the Conveyor and Elevator Belt Handbook, fire-resistant type conforming to the standards of Part 18.65, of the 30 CFR 1. Top belt cover thickness shall be 6.4 mm 1/4 inch with bottom cover 3.2 mm 1/8 inch thick. Belt edges shall have minimum 25 mm 1 inch flanges and shall be sealed by carrying the cover around the carcass edges during manufacture. Cover and skim coat material shall be comparable to those meeting the requirements of the RMA IP-1 for impact and abrasion resistance. The weight sensor shall be a heavy-duty, industrial, electronic force transducer flexure-mounted to the force collection system. Each sensor shall have a remote indicating meter and a six-digit totalizing counter located, installed, and connected in the boiler control panel. Unit frame shall provide rigid support for the material load, belt, and idlers. The unit shall be shop assembled complete with drive and all appurtenances, and shall be dust-tight in operation.

2.30.7 Track Hoppers

Track hoppers shall be standard double hopper design with a belt or vibrating-type feeder as indicated. The hoppers shall have a capacity of approximately [_____] metric tons tons and shall be constructed of not less than 9.5 mm 3/8 inch thick, Type 304L stainless steel plates, with slopes of not less than 55 degrees, and shall be stiffened with angles. The hoppers may also be of ASTM A36/A36M mild steel, minimum 6.4 mm 1/4 inch thick with replaceable liners 6.4 mm 1/4 inch thick, ASTM A167, Type 304L stainless steel. All rivets and field bolts inside the hopper shall have flat heads. The hopper shall be suspended from the track girders by heavy bolts and cast washers, or the sides shall be carried to the bottom of the track and supported by flanges fastened to concrete ledge continuously around the hopper with the concrete forming the top portion of hopper sides. Track girders shall consist of wide flange beams conforming to the AREMA Eng Man for loading plus impact. They shall be complete with bearing plates, WF cross struts, and rail clips. Top of hopper shall be fitted with properly sized sections of grating made with steel bars sized [_____] by [_____] mm inches, and cross rods [_____] mm inches in diameter, to form openings [_____] mm inches square.

2.30.7.1 Hopper Gates

A rack-and-pinion gate shall be provided at each hopper outlet and shall be a self-cleaning type. [Hand-] [Motor-] operated sliding plate shall be 9.5 mm 3/8 inch thick carbon steel, formed into the shape of a winged U. The gate plate surface shall be completely protected by an overlapping liner of 3.2 mm 1/8 inch thick ASTM A167, Type 304 stainless steel. The gate body material, except for the dust cover, shall be of 4.5 mm 3/16 inch thick ASTM A167, Type 304L stainless steel where in contact with coal flow.

2.30.7.2 Hopper Feeders

The vibrating or belt feeders of manufacturer's standard design shall be provided for the service required. Motor shall be [totally enclosed, nonventilated] [totally enclosed, fan-cooled type] [totally enclosed, fan-cooled type suitable for installation in a Class II, Division 1, Group F hazardous location in accordance with NFPA 70]. [Motor starter shall be [manual] [[magnetic] [across-the-line] [reduced voltage start]] type with [weather-resistant] [dust-tight] [explosion-proof] enclosure.]

2.30.8 Truck Hoppers

Truck hoppers shall be of standard double hopper design with a belt or vibrating type feeder as indicated. The hoppers shall have a capacity of approximately [_____] metric tons tons and shall be constructed of 9.5 mm 3/8 inch thick Type 304L stainless steel plates, minimum, with slopes of at least 55 degrees, and shall be stiffened with 6.4 mm 1/4 inch angles, minimum. The hopper may also be of ASTM A36/A36M mild steel, minimum 6.4 mm 1/4 inch thick, with replaceable liners 6.4 mm 1/4 inch thick, ASTM A167, Type 304L stainless steel. Rivets and field bolts inside the hopper shall be flat-head type. The hopper shall be supported by a flange fastened to the concrete ledge continuously around the hopper, with the concrete forming the top portion of hopper sides. Top of hopper shall be fitted with properly sized section of bar grating made with [_____] by [_____] mm inch mild steel bars and [_____] mm inch diameter cross rods to form openings [_____] mm inches square. A supporting beam not less than [_____] mm inches deep, [_____] kg/meter pounds/foot, in a wide flange member,

shall be provided under the grating.

2.30.8.1 Hopper Gates

A rack-and-pinion gate shall be provided at each hopper outlet and shall be a self-cleaning type. [Hand-] [Motor-] operated sliding plate shall be 9.5 mm 3/8 inch thick carbon steel, formed into the shape of a winged U. The gate plate surface shall be completely protected by an overlapping liner of 3.2 mm 1/8 inch thick ASTM A167, Type 304 stainless steel. The gate body material, except for the dust cover, shall be of 4.5 mm 3/16 inch thick ASTM A167, Type 304L stainless steel where in contact with coal flow.

2.30.8.2 Hopper Feeders

The vibrating or belt feeders, complete with control of manufacturer's standard design for the service required, shall be provided. Motor shall be [totally enclosed, nonventilated] [totally enclosed, fan-cooled] [totally enclosed, fan-cooled type, suitable for installation in a Class II, Division 1, Group F hazardous location in accordance with NFPA 70]. [Motor starter shall be [manual] [[magnetic] [across-the-line] [reduced voltage start]] type with [weather-resistant] [dust-tight] [explosion-proof] enclosure.]

2.30.9 Vibrator

Vibrator shall be electromagnetic type with variable power control that produces mechanical pulsating motion. The net weight of the vibrator shall be [_____] kg pounds and power input shall be [_____] watts, [_____] amperes at [_____] volts ac. Vibrator shall provide 3600 vibrations per minute or 7200 vibrations for heavy duty applications. The vibrator shall be semi-noiseless and shall be provided with mounting plates for welding to hoppers, as indicated, each complete with an eye bolt for attaching a safety chain. The electric control suitable for separate wall mounting shall be complete with an electronic valve for changing alternating current to mechanical pulsating waves and a dial switch or rheostat to vary the power of vibration. Vibrators shall be provided with Division I, Class II, Group F rating in the areas where coal dust is present, in accordance with NFPA 70.

2.30.10 Car Heaters

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NOTE: The designer shall determine if electrical facilities are sufficient to provide the power requirements of electric car heaters or if gas-fired heaters must be used. The designer will determine if the location and climatic conditions will require sidecar panels or undercar heaters, or a combination of both types of heaters.

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2.30.10.1 Gas-Fired Heaters

Gas-fired heaters shall be the infrared radiant type and shall be located between rails and along the walls of the shed. Heater shall have an input of approximately 90 kW 300,000 Btuh. Heater shall have perforated, heavy-gauge stainless steel cover that is not affected by water or coal falling from the car. Burner shall have windproof pilot, main gas

solenoid valve, and safety switch to interrupt gas supply to burner if pilot is not burning, and shall be furnished with manual cutoff valves and pressure regulator. Heater shall be supplied with electric blower for furnishing combustion air to the burner and with all other controls and accessories as recommended by the heater manufacturer for a complete installation, and shall comply with ANSI Z83.19/CSA 2.35 and UL 795.

2.30.10.2 Electric Infrared Radiant Heaters

Electric infrared radiant heaters shall be weatherproof car thawing equipment with radiating surfaces of alloy tubing enclosing electrically insulated conductors. The equipment shall be in modular lengths suitable for both 45 and 90 metric tons 50 and 100 tons capacity cars and shall be designed for [manual] [automatic] disconnection of units not required during thawing operations. Car heaters shall include sidecar or undercar heating banks, or both, capable of operating as independent units designed for maintaining a balanced three-phase distribution system. Heaters shall have heating conductor units, including factory assembled connections for attachment to water-tight terminal boxes, supported on corrosion-resistant metal framing and shall have rust-resistant steel reflectors with an approved coating. Heaters and connections shall be wired using NEMA 4 enclosures, in accordance with NEMA ICS 1, suitable for cleaning by hosing down with water.

2.30.11 Coal Spouts, Chutes, Inlet Boxes, and Outlet Hoppers

Coal spouts, chutes, inlet boxes, and outlet hoppers shall be constructed of ASTM A36/A36M steel members not lighter than 3.416 mm 10 gauge, adequately reinforced and braced with angle frames, and with all joints dust tight. Slopes shall be as steep as possible, but not less than 55 degrees off horizontal. Liners shall be stainless steel or ultra-high molecular weight polyethylene (UHMWP). If UHMWP liners are used, each side of chute at each floor level shall be provided with a warning sign "DANGER DO NOT WELD - FLAMMABLE PLASTIC LINER." Impact liners shall also be used. Access openings and inspection openings with cover plates shall be provided as indicated and required. [Silo frames shall be constructed of heavy channel frames the full size of the silo opening and shall be provided with concealed steam pipe and coil around opening.] [Outlet hoppers shall be provided with rack-and-pinion type gates and shall be lined with austenitic stainless steel [_____] mm inches thick, conforming to ASTM A167, Type 304L]. Rack-and-pinion gates shall be of the type specified for track hoppers.

2.30.12 Car Spotter

Car spotter shall be electric-motor driven having a capstan mounted vertically on a rigid housing that completely encloses the gears. The gears shall include helical gears and worm gear; the helical gears shall be fabricated of high grade steel accurately finished and splash-lubricated, and the worm gear shall be fabricated of bronze. All of the mechanism shall be mounted on a steel base rigidly welded to maintain alignment. The unit shall be coupled to, and driven by, a separate, [_____] W hp, totally enclosed, nonventilated, hoist-type motor with a full-load speed of 1720 rpm. The coupling shall be roller-chain flexible type enclosed in a revolving casing and protected by a heavy steel guard. The unit shall have a starting pull of 22 kN 5000 pounds, a running pull of 11 kN 2500 pounds, and an average rope speed not in excess of 230 mm/sec 45 fpm. The unit shall be complete with [_____] m feet of [32 mm 1-1/4 inch diameter manila rope with a breaking strength of 60 kN

13,500 pounds, minimum,] [19 mm 3/4 inch diameter marline-covered standard steel wire rope with a breaking strength of 170 kN 37,600 pounds, minimum,] and a steel car pulling hook with an allowable rope pull of 45 kN 10,000 pounds, so fabricated as to be readily attachable to, and removable from, the car frames.

2.30.13 Coal Bunkers

Suspension coal bunkers of size and capacity indicated shall be constructed of ASTM A36/A36M steel plate reinforced and braced as required and installed dust-tight. Bunkers shall be provided of a design optimized for coal flow, not susceptible to rat-holing or hangups. Cylindrical or silo type bunkers to reduce stagnation shall be provided for each boiler, each with conical discharge hoppers and slopes not less than 70 degrees. The outlet cone shall be manufactured of, or lined with, ASTM A167, Type 304 stainless steel. Bunkers shall be provided with rack and pinion type coal shutoff valves, self-cleaning, and dust tight. Valve materials exposed to flowing-coal shall be of corrosion resistant steel. An emergency diverter shall be provided for emptying the bunker.

2.30.14 Coal Storage Silos

2.30.14.1 Silo Design

Silo walls may be slip-formed, cast-in-place reinforced concrete, precast concrete, or other approved construction materials. Concrete shall have a 28-day compressive strength in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE. Silo roof shall be reinforced concrete complete with 600 mm 24 inch square, weatherproof, hinged access door. Handrail and steel toe-board shall be provided all around the roof of the silo. Live storage shelf for the silo shall be reinforced concrete, sloped not less than 60 degrees from horizontal and supported by steel beams corbelled from the inside walls of the silo. Live storage outlet hopper to chute and feeders shall be built of not lighter than 9.5 mm 3/8 inch steel. Silo reserve storage floor shall be reinforced concrete, sloped not less than 60 degrees and laid on well-tamped fill material. Reclaim outlet hopper to the chute feeding the flight feeder shall be built of not lighter than 9.5 mm 3/8 inch steel.

2.30.14.2 Silo Interior Finish

In a concrete stave silo, the interior finish shall consist of a three-coat concrete parget. A brush coat, scratch coat, and a finish trowel coat shall be applied, one after the other, to produce a smooth monolithic finish. The parget shall be worked into the vertical and horizontal grooves to permanently interlock the concrete staves.

2.30.14.3 Silo Exterior Finish

The exteriors of stave and concrete silos shall be covered with a brush coat of gray cement. This coating shall be applied over all hoops, lugs, and staves to produce a homogeneous finish.

2.30.14.4 Silo Level Controls

A normal high-level and emergency high-level control switch shall be mounted at the top of the silo to shut off the feeding system when the silo is full of coal. A low-level switch shall be furnished at the low level of the silo's live storage shelf, as indicated, to signal by light

that coal is at a low level in the live storage compartment. Switches shall also be furnished near the bottom of the silo, as indicated, to signal by light that coal is at a low level in the reserve storage compartment. Switches shall be for Class II, Division 1, Group F hazardous location in accordance with NFPA 70.

2.30.15 Coal Crusher

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NOTE: The designer shall select the appropriate type of crusher based on the throughput requirements and an economic analysis.
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Coal crusher shall be [roll crusher][hammermill][granulator][impactor] designed to reduce run-of-mine or lump coal to a maximum lump size of [_____] mm inches. Crusher shall have a minimum capacity of [_____] metric tons/hour tons/hour when handling average size bituminous coal. Housings shall be made of heavy castings or welded heavy steel plate. Interior of the housing shall have replaceable liners, constructed of abrasion resistant steel. Breaker plate, grates, rolling rings, swing hammers, and other parts of the unit subject to excessive wearing shall be replaceable. Crusher shall have provisions to trap and reject hard foreign objects without damaging the crusher. Shafts shall be forged, heat-treated alloy steel with bearings mounted in dust-tight housings. Motor shall be [totally enclosed, nonventilated type][totally enclosed, fan-cooled type][totally enclosed, fan-cooled type suitable for installation in a Class II, Division 1, Group F hazardous location in accordance with NFPA 70]. [Motor starter shall be [manual][[magnetic][across-the-line][reduced voltage start]] type with [general-purpose][weather-resistant][water-tight] [dust-tight][explosion-proof] enclosure.] Integral size motors shall be the premium efficiency type in accordance with NEMA MG 1.

2.30.16 Vibrating Feeders

Vibrating feeders shall be the [electromagnetic][electromechanical] [single input (Brute Force)] type with a capacity of 0 to [_____] metric tons/hourtons/hour when handling coal weighing approximately 800 kg/cubic meter 50 pcf and with maximum lump size of [_____] mm inches in diameter. Feeder pans and skirts shall be replaceable [6.4][9.5][12.7] mm [1/4][3/8][1/2] inch thick, Type 304 solid stainless steel plate without liners. The feeder pan shall be fabricated [_____] mm inches in width, [_____] mm inches in length and [_____] mm inches deep. Dust control covers of 3.416 mm No. 10 gauge thick steel shall be provided for each unit. [Two][Four] rectangular poke holes ([one][two] each side) shall be provided with 6.4 mm 1/4 inch thick No. 304 stainless steel sliding covers. All feeder parts coming in contact with coal shall be made of, or lined with, Type 304 stainless steel. All feeders shall automatically compensate for material headloads and weight effect to maintain a constant feed and must not damper out when operating under full silos or bins. Slopes on pan shall not exceed 10 degrees. The vibratory feeders shall be [foot][suspension] mounted and shall be completed with supports. Suspended feeders shall be provided with safety cables. The feeders shall have their drives located [above][below] trough. The motors shall be [totally enclosed, nonventilated type][totally enclosed, fan-cooled type suitable for installation in Class II, Division I, Group F hazardous location in accordance with NFPA 70]. Integral size motors shall be the premium efficiency type in accordance with NEMA MG 1.

2.30.17 Tripper

The tripper shall be of steel construction, motor-propelled, automatically reversible, or manually controlled. It shall be equipped with antifriction bearings throughout, rolled or forged steel wheels, hand-operated rail clamps for optional operation in a fixed location, scraper, and crossover walk with handrail. The traversing speed shall not exceed 127 mm/sec 25 fpm, and the motor shall include a motor brake. The chute shall be one way toward the center of the silo and shall slope at not less than 55 degrees. Its seal shall be provided with all necessary components for installation to suit the bunker/silo slot. Seal shall be of the plow type. The tripper shall be provided with [_____] W hp motor, all reversing and end travel limit switches, cable reel, and 14 No. 12 AWG conductor cable (13 slip rings) and supports for the starter. Two pushbutton stations shall be mounted, one on each side of the tripper. Both stations shall include forward-reverse and tripper stop-run pushbuttons. The conveyor frame shall include a ladder type cable tray to contain the cable from the reel. Reversing switches shall be mounted on the tripper and be actuated by track dogs to permit reversal of the tripper over each extreme silo. Limit switches shall be mounted on the tripper to operate immediately beyond both extreme limits of tripper reversal. A plugged chute switch shall also be furnished. All tripper controls, including limit switches and reversing switches shall be furnished in explosion-proof enclosures approved for Class II, Division 1, Group F service, in accordance with NFPA 70. The complete tripper shall also include pulley assemblies, shafts, bearings, carrying and return idlers, tripper framing, and supports.

2.30.18 Trackmobile

Trackmobile shall be provided with a [_____] liter cubic inch industrial gasoline engine for moving/switching [_____] rail cars on the track and hauling carts and other portable vehicles while traveling on its road wheels. The trackmobile shall be designed to ride on [_____] mm inch gauge track. Rail wheels shall be heat treated, cast steel, keyed on tapered axles, solidly mounted suspension system. Road wheels shall be, heavy duty, [_____] ply, [_____] by [_____] tires, roller-bearing mounted wheels, with retractable suspension. The coupler shall be heavy-duty, cast steel, remotely controlled from cab. Maximum speed shall be provided on rail km/hour mph low [_____], high [_____]; on road, low [_____], high [_____]. The trackmobile shall be able to operate on a maximum grade of [_____] percent and minimum curve of [_____] m foot radius. Trackmobile shall be also equipped with [air brakes] [self-energizing drum and shoe type, hydraulic service], cab heater and defroster, sanders, [electric horn] [air horn] strobe light, front and rear lights, backup alarm, [enclosed cab] [open cab] with windshield wipers [, radio remote control,] and power steering.

2.30.19 En-Masse Chain Conveyors

These conveyors shall move materials horizontally and/or vertically, with multiple discharge points and in a dust-tight and completely enclosed unit. Conveyors shall have a length as shown but not to exceed 75 m 250 feet. Conveyor capacity shall be [_____] metric tons/hour tons/hour when handling coal with approximate weight of 800 kg/cubic meter 50 pcf and with maximum lump size of [_____] mm inches diameter. Maximum capacity shall be based on a chain speed not to exceed 813 mm/second 160 fpm. Chain shall be drop-forged, case hardened, steel alloy of the

single-strand type with flights welded to the chain links or integral chain and flights type. The hardness of the links shall be 500-600 BHN. The conveyor casing shall be dust tight and shall be of 6.4 mm 1/4 inch thick ASTM A242/A242M high strength, low alloy steel with 3.416 mm No. 10 gauge cover of the same material. The casing shall be provided with T-1 steel (ASTM A514/A514M Type B) removable liners. The liners shall be 19 mm 3/4 inch thick on the bottom and 13 mm 1/2 inch thick on the sides, 19 mm 3/4 inch T-1 steel wear bars shall be provided for the empty run of the conveyor. Liners and wear bars shall be attached to the casing using countersunk stainless steel bolts with stainless steel nuts and washers. Drive sprocket shall be heat treated, induction hardened to a minimum depth of 6.4 mm 1/4 inch. Drive shaft shall be heat treated, designed, and sized based on ANSI/AGMA 6113AGMA 6013 requirements. Bearings shall be spherical double roller bearings. A dust seal shall be provided where the drive shaft ends go through the casing. The conveyor shall have inlet and outlet spouts, inspection doors giving access to the drive sprocket, cleaner, and wear surfaces. Chain tension is achieved by a screw take-up. Each discharge opening shall be provided with rack-and-pinion-operated gates with [hand wheels][motor operated][air operated]. Motor shall drive conveyor through a speed reduction unit which is either direct connected or roller chain connected to the drive shaft. Motor shall be [totally enclosed, nonventilated type][totally enclosed, fan cooled type][totally enclosed, fan-cooled type suitable for installation in a Class II, Division 1, Group F hazardous location in accordance with NFPA 70]. [Motor starter shall be [manual] [[magnetic] [across-the-line] [reduced voltage start]] type with [general-purpose][weather resistant] [water-tight][dust-tight][explosion-proof] enclosure.] Conveyor frame shall be constructed essentially as indicated, with support and additional bracing as required for rigidity. Integral size motors shall be the premium efficiency type in accordance with NEMA MG 1.

2.31 ASH HANDLING SYSTEM

2.31.1 Boiler Room Ash Handling System

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NOTE: When specifying boilers with capacity of 4.1 MW 14,000,000 Btuh per boiler or less, this paragraph and subsequent paragraphs will be deleted, except applicable portions.

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The ash handling system shall be the dry pneumatic type in stoker fired boilers. This system shall gather ash from the boiler forward ash discharge grate hopper and from [economizer] [air preheater] ash discharge hopper and other filtration systems and shall discharge to the ash storage silo located outside of the building. The entire system shall be coordinated to fit the equipment supplied. Ash dust control conditioners shall be used to reduce fugitive dust emissions during discharge of ash from the storage silo.

2.31.1.1 Ash Hopper

Ash removal hopper for each boiler shall be constructed of 6.4 mm 1/4 inch thick steel plate, minimum, with suitable external structural steel supports for connection to boiler ash hopper and necessary internal anchors for holding refractory lining in place. Refractory lining shall be 225 mm 9 inches thick on vertical walls and 150 mm 6 inches thick on feed

plates. Each hopper shall be furnished with a sliding ash gate. Each boiler sliding gate unit shall be provided with an access compartment to allow gathering and cooling of ash. A cast-iron grate shall be provided along with a manually-operated air-tight inlet valve for feeding ash into the pneumatic gathering line. A hinged, steel access gate shall be provided at each compartment. Spring loaded air intakes shall be provided at the end of each header. The structural integrity of the hopper shall be based on the ash weight of 1120 kg/cubic meter 70 pcf.

2.31.1.2 Clinker Grinder

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NOTE: Delete this paragraph if coal analysis indicates no possibility of slag formation.
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Clinker grinder unit shall be provided with [_____] mm inch wide double roll for each hopper outlet gate housing. The grinders shall have manganese steel rolls and cast-iron housings with grinder shafts mounted on outboard bearings protected by a stuffing box and gland assembly. Grinder shafts shall pass through stuffing boxes equipped with packing rings and lantern rings for seal water flow. Clinker grinder shall be provided with a reversing mechanism to reverse direction of the grinder rolls should an obstruction stall the grinder. A 9.5 mm 3/8 inch steel plate ejector feed hopper shall be furnished below each clinker grinder to feed the inlet of the pneumatic ash gathering system. Fixed passages in the clinker grinders shall prevent discharge of particles too large to be handled by the pneumatic conveying system. Each clinker grinder shall be driven by a totally enclosed type motor and shall be provided with a reversing starter, pressure switch for seal water control, diaphragm-operated seal water valve, and a solenoid valve. Units shall be designed for the characteristics of the coal specified and shall be capable of handling bottom ash at a rate exceeding the conveying system capacity.

2.31.1.3 Conveyor Piping

Conveyor pipe and fittings shall be made of an abrasive-resisting alloy metal cast by the sand-spun process, having a minimum Brinell hardness of 280. Wall thickness shall not be less than 13 mm 1/2 inch and pipe lengths shall not exceed 5.5 m 18 feet. Joints shall be made with flanges or sleeve pipe couplings and shall be airtight. Fittings shall have a Brinell hardness number of approximately 400 and shall be provided with removable wearbacks, where applicable, or shall be of the integral wearback type. Ash inlet fittings shall be designed so that the ash cannot overload or clog the conveyor pipeline. Suitable adjustable supports or hangers shall be provided. Vacuum hose connections shall be provided as indicated. Provide 4.6 meters 15 foot lengths of vacuum hose with quick connectors and four floor sweep-up nozzles.

2.31.1.4 Vacuum and Combination Vacuum/Pressure Systems

2.31.1.4.1 Vacuum System

The ash conveying equipment shall be pneumatic suction type, complete with vacuum pumps and all component parts necessary for complete and successful operation. The ash conveying equipment shall be sized approximately twice the predicted accumulation rate. The system shall have the capacity to convey and empty not less than [_____] metric tons/hour tons/hour of ash

weighing approximately [_____] kg/cubic meter pcf. The tonnage shall be based on average handling rate and not on the instantaneous rate.

2.31.1.4.2 Combination Vacuum/Pressure Systems

Vacuum/pressure equipment shall be commercially produced for this particular type of service and shall include a pressure vessel equipped with a filter section at the top and an aeration ring at the bottom. Material shall be drawn into the unit by vacuum, with the air separated from the material in the top filter section and exhausted through a silencer. A high level indicator within the vessel shall then reverse the action of the vacuum/pressure pump by aspirating air through a silencer and filter unit and discharging the pressurized air into the vessel. Part of the air shall be utilized to clean the filter and part of the air shall pass through the aeration ring of the vessel to pick up material and convey it under pressure to the storage silo. The unit shall be furnished complete with all automatic air control valves to control air flow to and from the vessel continuously through the two modes of the operating cycle. Unit operation shall continue automatically until switched off at the control cabinet. All automatic valves, interconnecting piping, and the vacuum/pressure vessel shall be skid-mounted. Vacuum/pressure pump shall be mounted separately. The control cabinet may be mounted separately or skid-mounted on the vacuum/pressure vessel skid. Capacity of the unit shall be approximately [_____] metric tons/hour tons/hour of ash weighing approximately [_____] kg/cubic meter pcf. Piping sizes for ash collection system shall be designed to fit the unit supplied. The vacuum/pressure system shall be used where storage silo is more than 150 m 500 feet from the boiler plant. A vacuum system should be used for capacities of less than 45 metric tons/hour 50 tons/hour per system.

2.31.1.4.3 Pump Unit

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NOTE: Where characteristics of the fly ash require additional treatment, a water spray shall be incorporated in the filtering unit. If not required, delete the portion included in the brackets. Air discharged to the atmosphere must meet the local air pollution standards.

****

Vacuum or vacuum/pressure pump unit shall be sized to match system design requirements. Pump unit shall be liquid-ring type having round rotor with curved blades rotating in an elliptical casing. Water alternately entering and leaving the chambers within the rotor vanes shall provide the required pumping action. Water within the casing shall act as an air cleansing agent and the operation and maintenance of the unit shall not be affected by dust-laden air. Unit shall be base-mounted with electric motor drive and all required heat exchangers, separators, and control valves. The vacuum pump inlet piping shall be provided with a vacuum filter unit to remove the fly ash obtained from the economizer ash hopper. The filter unit shall include a metal housing containing filter bags and an automatic air purge back-washing system.[A water spray shall be incorporated into the filtering unit.] The filtering unit shall remove all fly ash before discharge to the atmosphere.

2.31.1.4.4 Control Cabinet

Control cabinet for the complete operation of the system shall be supplied

and shall include all running indicating lights as required. A push-button switch shall be conveniently located in the boiler house to start and stop the system. A vacuum breaker, operating automatically from a timer, shall be provided in the bottom ash conveyor line to break the system vacuum.

2.31.1.4.5 Controls

Controls for a combination vacuum/pressure system shall have a selector switch set to automatic position to start the unit in the vacuum cycle. High-level indicator in vacuum/pressure vessel shall actuate necessary controls to cut off the vacuum gathering system and pressurize the vessel for pressure discharge of collected material. A low-pressure switch in the control panel shall sense the pressure drop in conveying pressure and shall return the unit to vacuum operation. The unit shall operate continuously in this manner until manually shut down. Setting selector switch in manual position shall shut the unit down after filling. Discharge shall then be accomplished by pressing the manual discharge button. A high vacuum switch with time delay shall be provided to shut the system down automatically in the event none of the inlet valves are actuated. Switches and controls shall be heavy-duty type in accordance with NEMA ICS 1.

2.31.1.4.6 Automatic Air Valve

Automatic air valve shall be provided at economizer or air preheater ash inlet hopper discharge slide gate to allow air into system without causing a vacuum within the boiler ash hopper. Slide gate shall be provided as part of the ash system and shall be manually-operated and interlocked to actuate the automatic air inlet valve.

2.31.1.5 Ash Silo

The ash storage silo shall have a capacity of not less than [_____] metric tons tons of ash and fly ash considered to have an average weight of [_____] kg/cubic meter pcf. This capacity shall be based on a minimum of 24 hours[60 hours if ash cannot be removed on weekends]. The silo shall be made of welded steel with a cone bottom for truck filling and shall be supported on a structural steel tower. All elements exposed to the exterior shall be designed for wind loads of [_____] kg/square meter psf. A 4.3 m 14 foot clearance shall be provided under the hopper outlet fitting or appurtenance. Silo shall be provided with steel ladder and safety cage from the ground level to roof, steel ladder inside storage bin, and an angle railing around the roof perimeter. Minimum plate thickness shall be 6.4 mm 1/4 inch. Silo shall be complete with all accessories required for an operable installation including, but not limited to, high ash level detector, roof manhole, pressure and relief valve, and other roof openings, as necessary. Interior coating shall be coal-tar epoxy conforming to SSPC Paint 16.

a. Ash storage silo for vacuum system shall be provided with two stage separators[and a tertiary bag filter]. The primary receiver shall be cylindrical and shall be constructed entirely of sectional steel or cast plates suitable for this special service. The receiver shall be not less than 900 mm 3 feet in diameter. Flanges and bolts shall be on the outside, and the impact of ash shall be directed against heavy iron wear plates of abrasive-resistant alloy. The receiver shall be provided with an air-tight discharge passage not less than 450 mm 18 inches in diameter for free flow of clinkers. The receiver shall have

means for positive, periodic, and automatic operation in dumping its entire contents into the silo; in addition, the system shall be so designed that all suction is positively shut off from the receiver during its dumping period so that no dust can be sucked out through the exhaust while the discharge of the receiver is open or opening. The air from the primary receiver shall enter an external secondary separator which shall remove 90 percent of the dust not collected by the primary receiver. The combined efficiency of the primary and external secondary separators[and tertiary bag filter] shall be not less than 98 percent. The secondary separator shall be similar to the primary receiver in construction, but may be smaller and of lighter material. No part of the discharger shall extend into the main storage bin. A housing constructed of 6.2 mm 1/4 inch steel plate with a tight-closing access door shall be provided as an enclosure for the discharger.

b. The silo vent filter unit shall be mounted on top of the silo and shall act as an air release unit to separate the air from the ash. The ash shall drop into the silo. Back cleaning of the bag filters shall be automatic, utilizing plant air at approximately 690 to 860 kPa 100 to 125 psig. Back cleaning unit shall be actuated whenever the ash handling system is in use. Dust released from the filter bags in the back cleaning operation shall fall into the storage silo. Housing shall be provided to allow the unit to operate exposed to the weather in ambient temperatures ranging from minus 40 to plus 55 degrees C minus 40 to plus 130 degrees F.

c. A rotary, dustless unloader shall be provided to eliminate all dust in unloading ash and dust from the ash storage silo. No water shall be added to the ashes in the conveyor or in the storage bin. The dustless unloader shall add water to the ash in controlled quantities so that no surplus water runs or drips from the ash after discharge. The discharged ash shall be muddy but loose and free flowing. Water valve shall open only when drive motor is running. Unloader shall have a capacity of not less than 27 metric tons 30 tons of conditioned ash per hour. The rotating unit shall be designed so that all bearings are located on the outside and not in contact with the material handled. Platform shall be provided for access to unit and shall have a handrail and a safety ladder to grade. Motor shall be totally enclosed type for outdoor operation. [Motor starter shall be [manual][[magnetic] [across-the-line][reduced voltage start]] type with [weather-resistant][water-tight][dust-tight] enclosure.]

2.31.1.6 Conveyor Type Ash Handling System

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NOTE: When specifying boilers with capacity greater than 4.1 Megawatts 14 million Btuh per boiler, the following paragraphs will be edited.

****

Ash pits shall be funnel shaped, constructed of 6.2 mm 1/4 inch steel plate, minimum, and covered with a heavy grating with openings approximately 50 mm 2 inches square. Ashes and clinkers shall be discharged from the boiler ash hoppers into ash pits located directly below the ash hopper doors. A combination drag chain conveyor for horizontal conveying and an elevator conveyor for vertical conveying of ashes shall be arranged, as indicated, to take ashes from the bottom of the ash pits for discharge into the ash silo. Conveyors shall have a

capacity of not less than [_____] metric tons/hour tons/hour when handling ashes weighing approximately [_____] kg/cubic meter pcf at a maximum speed of 508 mm/sec 100 fpm. Doors shall be provided for access to all parts, as required. Motor shall be [totally enclosed, nonventilated type] [totally enclosed, fan-cooled type] [totally enclosed, fan-cooled type suitable for installation in a Class II, Division 1, Group F hazardous location in accordance with NFPA 70]. [Motor starter shall be [manual][[magnetic] [across-the-line][reduced voltage start]] type with [general-purpose][weather-resistant][water-tight][dust-tight][explosion-proof] enclosure.]

2.31.1.6.1 Drag Chain Conveyor

Drag chain conveyor shall be of a single strand of wide, heat treated, high alloy, drop forged, rivetless drag chain with a [_____] mm inch pitch, [_____] mm inch overall width, and [_____] kg pounds working strength, and shall have a hardness of 460-510 Brinell. The upper strand of the chain shall convey the ash in a trough constructed of 9.5 mm 3/8 inch cast-iron extending from [_____] mm inches in front of the foot shaft to [_____] mm inches behind the head shaft and set flush with the floor. The return strand of chain shall be carried in angle runways set flush with the trench floor. The drag chain conveyor shall be driven by a [_____] mm inch pitch roller chain and [_____] mm inch pitch diameter, [_____] tooth sprocket on the drive shaft, and a [_____] mm inch pitch diameter, [_____] tooth sprocket on the elevator foot shaft.

2.31.1.6.2 Casing

The casing shall be constructed of 2.656 mm 12-gauge thick steel, minimum, with 9.5 mm 3/8 inch thick boot plates. The head-end drive shall include a gear motor and steel roller chain complete with drive brackets, guards, and backstop. The elevator shall be equipped with head-end platform and ladder.

2.31.2 Ash Handling Controls

The ash handling system control panel shall contain all necessary instrumentation, including selector switches, annunciators, push buttons, and ammeters required for monitoring and operation of the ash handling system. The panel shall graphically display the system. In addition, the panel shall contain all necessary timers, relays, and terminal blocks that are required for the control system. Control and monitoring of the ash removal system shall be from a single panel. This panel shall have push buttons to start automatic operation of each system and also push buttons for individual control of each component. The panel shall have sufficient instrumentation to observe the removal operations and controls to permit effective emergency control. Local control stations at each ash removal point for local manual operation shall also be provided. Local selector switches shall be provided so that equipment may be operated manually for test and maintenance purposes. The operation of the bottom ash system shall be controlled by a microprocessor-based control system, a solid-state programmable controller or an electromechanical system. All controls and instrumentation for location indoors shall have NEMA 12 rating in accordance with NEMA ICS 1. All outdoor components shall have NEMA 4 rating, in accordance with NEMA ICS 1. All major equipment components, including control panels and devices, shall be factory-mounted, prewired, tubed, and tested to the maximum practical extent. The system shall include controls for fully automatic and sequential operation of the ash handling system. These controls shall be

designed so that manual steps, such as continuous monitoring and regulation, will not be required. Suitable safety interlocks shall be incorporated to assure that proper permissive conditions have been met prior to changing the operating status of major system components. Shutdown of the ash handling system, or portion thereof, shall be automatically initiated, with alarms, should unsafe conditions arise during operation of the system. Facilities for monitoring and control of the ash handling system shall be provided for the following functions:

a. Manual start of the automatic control operations.

b. Selection of operating components.

c. Override of the automatic control sequences, both at the ash handling control panel and locally.

d. Manual operation, either remotely from the control center or locally.

e. Emergency shutdown on a unit or system basis.

f. Status monitoring at the ash handling control panel of the operation of the ash handling system and its components.

The automatic controls for bottom ash collection transport shall operate as specified. When a start command has been manually initiated, the automatic ash collection and transport sequences for the unit shall progress through their complete cycles, and after completion of the cycles, the system shall automatically shut down. The system shall include an annunciator system, complete with audio and visual alarms, as part of the ash handling control panel. The annunciator system shall receive inputs from devices and system logic which shall indicate any out of specification or trip condition. Recorders shall be furnished to provide a permanent record of selected variables that relate to the ash handling system's performance and operation. Control stations supplied with analog control loops shall provide bumpless transfer between the manual and automatic modes of operation. The manual mode of operation shall provide direct control of the end device with no intervening analog control components unless those components are powered by the same source as the end device.

2.31.3 Submerged Drag Chain Conveyor (SDCC)

Submerged drag chain conveyor shall be designed to extract ash at normal capacity [_____] metric tons/hour TPH and maximum capacity [_____] metric tons/hour TPH, based on a dry ash density of approximately [_____] kg/cubic meter pcf. The maximum chain speed shall be 76 mm/second 15 fpm. The SDCC shall be designed for continuous operation and shall have a storage capacity of [_____] cubic meter cu ft accumulation. The SDCC shall have an upper compartment filled with water and a dry lower compartment. The equipment shall be provided to maintain water temperature at approximately 60 degrees C 140 degrees F. The dewatering slope shall be at an angle of [_____] degrees with the horizontal. The top trough shall be not less than 9.5 mm 3/8 inch thick carbon steel plate, welded construction, lined with renewable abrasion resistant steel wear plates, with a minimum thickness of 13 mm 1/2 inch and 300 BHN. All welds shall be ground smooth. The necessary track guide angles, hold-down angles, and carbon steel chain protectors shall be provided. The minimum depth of water in the upper trough shall be [_____] m feet. The return chain bottom trough shall be dry, constructed of 9.5 mm 3/8 inch thick

steel plate, stiffened and braced with structural shapes and shall be water-tight. Chain track angles shall be provided with a minimum 13 mm 1/2 inch thick steel replaceable wear flats with a minimum 300 BHN. Wear strips shall be also provided under the return flights, minimum 13 mm 1/2 inch thick and 50 mm 2 inch wide. The conveyor chain shall be a double strand round-link or ship-type chain, case hardened, corrosion and abrasion resistant, chrome-nickle-alloy, annealed and carburized with surface hardness between 500-600 BHN. Design strength and pitch shall be based on operating conditions. The conveyor flights shall be [_____] mm inches deep by [_____] mm inches thick T-1 steel plates attached on both ends to the chain. The flight shall be provided with top wear pads and bottom wear strips of abrasion resistant steel plate of 300 BHN minimum. A chain tensioner shall be provided at the tail end of SDCC for maintaining proper tension in both strands of the chain. The assembly shall include cast-iron idler wheel, bearings, shaft, guide block and bearing housing. Idler assemblies for both troughs shall include heavy duty spherical roller type bearings with external lubrication fittings. The chain drive assembly shall include cast-iron wheels with removable, surface hardened, toothed segments, drive shaft, bearings. The conveyor shall be driven by a hydrostatic drive unit coupled with a low speed, high torque hydraulic motor, built-in torque limiting valves for preventing damage to load train or electric motor. Speed regulation, self-lubrication, internal cooling, and dynamic braking shall be provided with this drive. Inching capability shall be provided. Hinged inspection doors, windows, and removable panels shall be provided along the conveyor to permit access and observation at critical points. All inspection doors, windows, and removable panels in mild steel shall be provided with stainless steel hardware and must be made completely water-tight. Water cooling and drainage connections shall be provided through flanged connections to the conveyor trough. Provision shall be made for continuous water flow into the top trough of the conveyor including two overflow connections, one for normal level and one high level; including high level alarm and an overflow weir box to prevent drain clogging. Chain cleaning spray shall also be provided.

2.31.4 Dense Phase Ash Handling

The ash conveying system shall be pneumatic dense phase type, complete with transfer vessels, solenoid valves, air receiver tank, air producer, and ash conveying piping. The ash handling system shall be designed to handle [_____] metric tons/hour tons/hour of ash weighing approximately [_____] kg/cubic meter pcf. Each transport vessel shall be bolted to the hopper discharge flange where ash shall flow into the vessel by gravity until a level indicator indicates the vessel is full. The transport vessel inlet valve then closes, and transport air between 175 to 350 kPa 25 to 50 psi enters the vessel through a fluidizing unit located at the bottom of the vessel. When the vessel has been brought to transport air pressure, the transport line valve opens and a "slug" of fly ash is transported to the storage silo. The transporting pipe shall be Schedule 40 standard black iron pipe [_____] mm inches diameter. The material velocities in the transportation pipe shall be [_____] meters/second fpm. The system shall be provided with 210 to 410 kPa 30 to 60 psi compressed air to fluidize and transmit ash. The conveying velocity shall not exceed 5.1 meters/second 1000 fpm.

2.31.5 Fly Ash Collectors

Fly ash collectors shall be as specified in Section 44 10 00 AIR POLLUTION CONTROL. Fly ash collectors shall be sized to handle total flue gas at

maximum boiler load and stack temperature, and shall be provided along with induced draft equipment. Fly ash collector requirements shall be coordinated with boiler draft and control requirements.

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 discrepancy before performing the work.

3.2 EARTHWORK

Excavation and backfilling for tanks and piping shall be as specified in Section 31 00 00 EARTHWORK, except backfill for fiberglass reinforced fuel tanks shall conform to the manufacturer's installation instructions.

3.3 EQUIPMENT ERECTION

Install boiler and auxiliary equipment as indicated and in accordance with manufacturers' instructions. Submit detail drawings, consisting of schedules, performance charts, brochures, diagrams, drawings, and instructions necessary for installation of the steam-generating units and associated equipment. Include drawings for piping, pipe anchors, wiring devices, trenches and related foundations, and setting plans certified by the boiler manufacturer and burner manufacturer including coal and ash handling equipment. Drawings shall indicate clearances required for maintenance and operation and shall also contain 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. Include manufacturer's written instructions indicating optimum pressures at all manometer connectors.

3.4 STORAGE TANK INSTALLATION

Install storage tank in accordance with Section 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS.

3.5 PIPING INSTALLATION

Pipe shall be cut accurately to measurements established at the jobsite, shall be installed without cold springing, and shall properly clear windows, doors, and other openings. Cutting or other weakening of the building structure to facilitate piping installation will not be permitted. Pipes shall be free of burrs, oil, grease, and other foreign matter. Pipes shall be installed to permit free expansion and contraction without damaging building structure, pipe, joints, or hangers. Changes in direction shall be made with fittings, except that bending of pipe 100 mm 4 inches and smaller will be permitted provided a pipe bender is used and wide sweep bends are formed. The centerline radius of bends shall not be less than 6 diameters of the pipe. Bent pipe showing kinks, wrinkles, flattening, or other malformations will not be accepted. Carbon steel piping to be bent shall conform to ASTM A53/A53M, Grade A, standard, or Grade B extra-heavy weight. Vent pipes shall be carried through the roof as directed and shall be properly flashed. Unless otherwise indicated, horizontal supply mains shall pitch down in the direction of flow, with a grade of not less than 25 mm in 12 m 1 inch in 40 feet. Open ends of pipelines and equipment shall be properly capped or plugged during

installation to keep dirt or other foreign materials out of the systems. Pipe not otherwise specified shall be uncoated. Unless otherwise specified or shown, connections to equipment shall be made with malleable-iron unions for steel pipe 65 mm 2-1/2 inches or less in diameter and with flanges for pipe 80 mm 3 inches or more in diameter. Unions for copper pipe or tubing shall be brass or bronze. Connections between ferrous piping and copper piping shall be electrically isolated from each other with dielectric couplings or other approved methods. Reducing fittings shall be used for changes in pipe sizes. In horizontal steam lines, reducing fittings shall be the eccentric type to maintain the top of the lines at the same level.

3.5.1 Pipe Sleeves

Pipe passing through concrete or masonry walls or concrete floors or roofs shall be provided with pipe sleeves fitted into place at the time of construction. A waterproofing clamping flange shall be installed as indicated. Sleeves shall not be installed in structural members except where indicated or approved. All rectangular and square openings shall be as detailed. Each sleeve shall extend through its specified wall, floor, or roof, and shall be cut flush with each surface, except that sleeves through floors and roofs shall extend above the top surface at least 150 mm 6 inches for proper flashing or finishing. Membrane clamping rings shall be provided where membranes are penetrated. Unless otherwise indicated, sleeves shall be sized to provide a minimum clearance of 6 mm 1/4 inch between bare pipe and sleeves or between jacket over insulation and sleeves. Sleeves in bearing walls, waterproofing membrane floors, and wet areas shall be galvanized steel pipe. Sleeves in nonbearing walls, floors, or ceilings may be galvanized steel pipe, or galvanized sheet metal with lock-type longitudinal seam. Except in pipe chases or interior walls, the annular space between pipe and sleeve or between jacket over insulation and sleeve in nonfire rated walls and floors shall be sealed as indicated and specified in Section 07 92 00 JOINT SEALANTS, and in fire rated walls and floors shall be sealed as indicated and specified in Section 07 84 00 FIRESTOPPING. Metal jackets for insulated pipes passing through exterior walls, firewalls, fire partitions, floors, and roofs shall not be thinner than 0.15 mm 0.006 inch thick aluminum if corrugated, and 0.41 mm 0.016 inch thick aluminum if smooth, and shall be secured with aluminum or stainless steel bands not less than 9.5 mm 3/8 inch wide and not more than 200 mm 8 inches apart. Where penetrating roofs, before fitting the metal jacket into place, a 13 mm 1/2 inch wide strip of sealant shall be run vertically along the inside of the longitudinal joint of the metal jacket from a point below the backup material to a minimum of 900 mm 36 inches above the roof. If the pipe turns from vertical to horizontal, the sealant strip shall be run to a point just beyond the first elbow. When penetrating waterproofing membrane for floors, the metal jacket shall extend from a point below the backup material to a minimum distance of 50 mm 2 inches above the flashing. For other areas, the metal jacket shall extend from a point below the backup material to a point 300 mm 12 inches above floor; or when passing through walls above grade, jacket shall extend at least 100 mm 4 inches beyond each side of the wall.

3.5.1.1 Pipes Passing Through Waterproofing Membranes

In addition to the pipe sleeves referred to above, pipes passing through roof or floor waterproofing membrane shall be provided with a 1.8 kg 4 poundlead flashing or a 448 g 16 ounce copper flashing, each within an integral skirt or flange. Flashing shall be suitably formed, and the

skirt or flange shall extend not less than 200 mm 8 inches from the pipe and shall set over the roof or floor membrane in a troweled coating of bituminous cement. The flashing shall extend up the pipe a minimum of 250 mm 10 inches above the roof or floor. The annular space between the flashing and the bare pipe or between the flashing and the metal-jacket-covered insulation shall be sealed as indicated. Pipes up to and including 250 mm 10 inches in diameter passing through roof or floor waterproofing membrane may be installed through a galvanized steel sleeve with caulking recess, anchor lugs, flashing clamp device, and pressure ring with brass bolts. Waterproofing membrane shall be clamped into place and sealant shall be placed in the caulking recess. In lieu of a waterproofing clamping flange and caulking and sealing of annular space between pipe and sleeve or conduit and sleeve, a modular mechanical-type sealing assembly may be installed. The seals shall consist of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe/conduit and sleeve with corrosion protected carbon steel bolts, nuts, and pressure plates. The links shall be loosely assembled with bolts to form a continuous rubber belt around the pipe with a pressure plate under each bolt head and each nut. After the seal assembly is properly positioned in the sleeve, tightening of the bolts shall cause the rubber sealing elements to expand and provide a water-tight seal between the pipe/conduit and the sleeve. Each seal assembly shall be sized as recommended by the manufacturer to fit the pipe/conduit and sleeve involved. The Contractor electing to use the modular mechanical type seals shall provide sleeves of the proper diameters.

3.5.1.2 Optional Counterflashing

As alternates to caulking and sealing the annular space between the pipe and flashing or metal-jacket-covered insulation and flashing, counterflashing may be accomplished by one of the following methods:

a. Standard roof coupling for threaded pipe up to 150 mm 6 inches in diameter.

b. Lead flashing sleeve for dry vents and turning the sleeve down into the pipe to form a waterproof joint.

c. A tack-welded or banded-metal rain shield around the pipe and sealing as indicated.

3.5.2 Pipe Joints

Joints between sections of pipe and fittings shall be welded or flanged. Except as otherwise specified, fittings 25 mm 1 inch and smaller shall be threaded; fittings 32 mm 1-1/4 inches up to, but not including, 65 mm 2-1/2 inches may be either threaded or welded; and fittings 65 mm 2-1/2 inches and larger shall be either flanged or welded. Pipe and fittings 32 mm 1-1/4 inches and larger installed in inaccessible conduits or trenches beneath concrete floor slabs shall be welded. Connections to equipment shall be made with black malleable-iron unions for pipe 50 mm 2 inches or smaller in diameter, and with flanges for pipe 65 mm 2-1/2 inches or larger in diameter.

3.5.2.1 Threaded Joints

Threaded joints shall be made with tapered threads properly cut and shall be made perfectly tight with a stiff mixture of graphite and oil, or

polytetrafluoroethylene tape or equal, applied to the male threads only, and in no case to the fittings.

3.5.2.2 Welded Joints

Welded joints shall be fusion welded in accordance with ASME B31.1, unless otherwise required. Changes in direction of piping shall be made with welding fittings only; mitering or notching pipe to form elbows and tees or other similar type construction will not be acceptable. Branch connections may be made with either welding tees or forged branch outlet fittings, either being acceptable without size limitation. Branch outlet fittings, where used, shall be forged, flared for improvement flow where attached to the run, reinforced against external strains, and designed to withstand full pipe bursting strength.

3.5.2.2.1 Beveling

Field and shop bevels shall be in accordance with the recognized standards and shall be done by mechanical means or flame cutting. Where beveling is done by flame cutting, surfaces shall be cleaned of scale and oxidation before welding.

3.5.2.2.2 Alignment

Parts to be welded shall be aligned so that no strain is placed on the weld when finally positioned. Height shall be so aligned that no part of the pipe wall is offset by more than 20 percent of the wall thickness. Flanges and branches shall be set true. This alignment shall be preserved during the welding operation. Tack welds shall be of the same quality and made by the same procedure as the completed weld; otherwise, tack welds shall be removed during the final welding operation.

3.5.2.2.3 Erection

Where the temperature of the component parts being welded reaches 0 degrees C 32 degrees F or lower, the material shall be heated to approximately 38 degrees C 100 degrees F for a distance of 900 mm 3 feet on each side of the weld before welding, and the weld shall be finished before the materials cool to 0 degrees C 32 degrees F.

3.5.2.2.4 Defective Welding

Defective welds shall be removed and replaced. Repairing of defective welds shall be in accordance with ASME B31.1.

3.5.2.2.5 Electrodes

After filler metal has been removed from its original package, it shall be protected or stored so that its characteristics or welding properties are not affected. Electrodes that have been wetted or that have lost any of their coating shall not be used.

3.5.2.3 Flanges and Unions

Flanges and unions shall be faced true and made square and tight. Gaskets shall be nonasbestos compressed material in accordance with ASME B16.21, 1.6 mm 1/16 inch thickness, full face or self-centering flat ring type. The gaskets shall contain aramid fibers bonded with styrene butadiene rubber (SBR) or nitrile butadiene rubber (NBR). NBR binder shall be used

for hydrocarbon service. Union or flange joints shall be provided in each line immediately preceding the connection to each piece of equipment or material requiring maintenance, such as coils, pumps, control valves, and other similar items.

3.5.3 Supports

3.5.3.1 General

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NOTE: Mechanical and electrical layout drawings and specifications for ceiling suspensions should contain notes indicating that hanger loads between panel points in excess of 23 kg 50 pounds shall have the excess hanger loads suspended from panel points.

****

Hangers used to support piping 50 mm 2 inches and larger shall be fabricated to permit adequate adjustment after erection while still supporting the load. Pipe guides and anchors shall be installed to keep pipes in accurate alignment, to direct the expansion movement, and to prevent buckling, swaying, and undue strain. All piping subjected to vertical movement when operating temperatures exceed ambient temperatures, shall be supported by variable spring hangers and supports or by constant support hangers. [Pipe hanger loads suspended from steel joist between panel points shall not exceed 23 kg 50 pounds. Loads exceeding 23 kg 50 pounds shall be suspended from panel points.]

3.5.3.2 Seismic Requirements

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NOTE: Provide seismic requirements if a Government designer (either 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. Pertinent portions of UFC 3-301-01 and Sections 13 48 73 and 23 05 48.19, properly edited, must be included in the contract documents.

****

Seismic Requirements for Pipe Supports and Structural Bracing: All piping and attached valves shall be supported and braced to resist seismic loads as specified under UFC 3-301-01 and Sections 13 48 73 SEISMIC CONTROL FOR MECHANICAL EQUIPMENT and 23 05 48.19 [SEISMIC] BRACING FOR HVAC[as shown.] Structural steel required for reinforcement to properly support piping, headers, and equipment, but not shown, shall be provided under this section. Material used for supports shall be as specified under Section 05 12 00 STRUCTURAL STEEL.

3.5.3.3 Structural Attachments

Structural steel brackets required to support piping, headers, and equipment, but not shown, shall be provided under this section. Material used for supports shall be as specified under Section 05 12 00 STRUCTURAL STEEL.

3.5.4 Anchors

Anchors shall be provided wherever necessary or indicated to localize

expansion or prevent undue strain on piping. Anchors shall consist of heavy steel collars with lugs and bolts for clamping and attaching anchor braces, unless otherwise indicated. Anchor braces shall be installed in the most effective manner to secure the desired results, using turnbuckles where required. Supports, anchors, or stays shall not be attached where they will injure the structure or adjacent construction during installation or by the weight of expansion of the pipeline.

3.5.5 Pipe Expansion

3.5.5.1 Expansion Loops

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NOTE: Wherever possible, provision for expansion of steam supply and return pipes will be made by changes in the direction of the run of the pipe or by field-fabricated expansion bends.

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Expansion loops shall provide adequate expansion of the main straight runs of the system within the stress limits specified in ASME B31.1. The loop shall be cold-sprung and installed where indicated. Pipe guides shall be provided as indicated. Except where otherwise indicated, expansion loops and bends shall be utilized to absorb and compensate for expansion and contraction instead of expansion joints.

3.5.5.2 Expansion Joints

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NOTE: If expansion joints are not required, this paragraphs will be deleted. Where space limitations prevent such provisions for expansion, expansion joints will be installed, and blanks will be filled as appropriate.

****

Expansion joints shall provide for either single or double slip of the connected pipes, as required and indicated. Initial setting shall be made in accordance with the manufacturer's recommendations to allow for ambient temperature at time of installation. Pipe alignment guides shall be installed as recommended by the joint manufacturer, but in any case shall not be more than 1.5 m 5 feet from expansion joint, except in lines 100 mm 4 inches or smaller where guides shall be installed not more than 600 mm 2 feet from the joint.

3.5.6 Valves

Gate or globe valves shall be installed with stems horizontal or upright. Swing check valves shall be installed in horizontal piping with the cap or bonnet up, or in vertical piping with the flow upward. Lift or piston check valves shall be installed in horizontal piping with the cap or bonnet up.

3.6 BURIED PIPING INSTALLATION

3.6.1 Protective Coating for Underground Steel Pipe

All steel pipe installed underground shall be given a protective covering, mechanically applied in a factory or field plant especially equipped for

the purpose. Specials and other fittings which cannot be coated and wrapped mechanically shall have the protective covering applied by hand, preferably at the plant, applying the covering to the pipe. Coatings shall not be field applied until the piping has satisfactorily passed the leak or hydrostatic test. All field joints shall be coated and wrapped by hand. All hand coating and wrapping shall be done in a manner and with materials that will produce a covering equal in effectiveness to that of the mechanically-applied covering.

3.6.2 Cleaning of Surfaces to be Coated

Steel surfaces shall be solvent-washed to assure an oil-and-grease-free surface and blast-cleaned to bare metal as specified in SSPC SP 6/NACE No.3. Areas that cannot be cleaned by blasting shall be cleaned to bare metal by powered wire brushing or other mechanical means. The air supply for blasting shall be free from oil and moisture. Following cleaning, the surfaces shall be wiped with coal-tar solvent naphtha and allowed to dry. The surfaces to be coated shall be free of all mill scale and foreign matter such as rust, dirt, grease, oil, and other deleterious substances. Surfaces shall be coated as soon as practicable after the cleaning operation.

3.6.3 Coating Materials

Buried steel piping shall be coated with one of the following methods:

3.6.3.1 Bituminous Pipe Coating

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NOTE: If coating system similar to coal tar coating and wrapping is required using different materials, this paragraph shall be rewritten. If double wrap system is required, the designer shall remove the brackets.

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Bituminous protective system shall be a coal-tar enamel and primer coating system, and shall consist of a coal-tar priming coat, a coal-tar enamel coat, a wrapper of coal tar saturated felt, and a wrapper of kraft paper, or a coat of water-resistant whitewash, applied in the order named and conforming to the requirements of AWWA C203 in all respects as to materials, methods of application, tests, and handling, except that an interior lining shall not be applied.[In addition, where excessively corrosive soils are encountered, the piping shall be given a second coating of coal-tar enamel and a second wrapper of felt.] Joints and fittings shall be coated and wrapped.

3.6.3.2 Polyethylene Pipe Coating

Continuous extruded polyethylene coating and adhesive undercoat application procedure, including surface preparation, shall be a factory-applied system conforming to NACE SP0185, Type A. Joints, valves, flanges, and other irregular surfaces shall be tape-wrapped as outlined under the tape-wrapping system, except that the tape shall be applied half-lapped, and all extruded polyethylene coating and adhesive undercoat surfaces to be tape-wrapped shall be primed with a compatible primer before application of tape. The primer shall be as recommended by the tape manufacturer and approved by the applicator of the extruded polyethylene coating. Damaged areas of extruded polyethylene coating

shall be repaired by tape-wrapping as described under the tape-wrapping system, except that any residual material from the extruded polyethylene coating shall be pressed into the break or shall be trimmed off. All areas to be taped shall be primed and the tape shall be applied half-lapped.

3.6.3.3 Tape-Wrap Pipe Coating

Cleaned surfaces shall be primed before applying tape as recommended by the manufacturer of the tape. The tape shall be an approved, pressure-sensitive, organic plastic tape with a minimum nominal thickness of 0.51 mm 0.020 inch. The tape shall conform to ASTM G21 for fungus resistance. Tape shall be applied to clean, dry, grease-free, and dust-free surfaces only. Weld beads shall be wire-brushed. All burrs and weld spatter shall be removed. Weld beads shall be covered with one wrap of tape before spiral wrapping. At each end of straight runs, a double wrap of one full width of tape shall be applied at right angles to the axis of the spiral wrapping. Kraft paper protective wrapping, if any, shall be removed from the pipe before the tape is applied. Material which is wrapped before it is placed in its final position shall have the wrapping protected at sling points with roofing felt or other approved heavy shielding material, or shall be handled with canvas slings. Damaged wrapping shall be repaired as specified. Pipe in straight runs shall be wrapped spirally, half-lapping the tape as it is applied. For pipe smaller than 100 mm 4 inches, one layer half-lapped shall be used. For pipe 100 mm 4 inches and larger, two layers half-lapped shall be used with the second layer wrapped opposite-hand to the first. Joints, coupling fittings, and similar units, and damaged areas of wrapping, shall be wrapped spirally beginning with one complete wrap 75 mm 3 inches back from each edge of the corresponding size of straight pipe. On irregular surfaces such as valves and other accessories, one layer half-lapped and stretched sufficiently to conform to the surface shall be applied, followed by a second layer half-lapped and applied with tension as it comes off the roll.

3.6.3.4 Epoxy Coating System

The epoxy coating system shall conform to AWWA C213, Type II. Fittings, valves, and joints shall be factory coated with materials identical to those used on the pipe, or may be field coated with a two-part epoxy system recommended by the manufacturer of the pipe coating system. Field protection may also be provided for joints and fittings with a coal tar tape hot-applied over a compatible primer.

3.6.3.5 Coating Inspection and Testing

After field coating of the pipe joints, the entire pipe shall be inspected with an electric holiday detector having an operating crest voltage of from 12,000 to 15,000 volts when using a full-ring, spring-type coil electrode. The holiday detector shall be equipped with a bell, buzzer, or other audible signal which operates when a holiday is detected. All detected holidays in the protective covering shall be repaired. Occasional checks of holiday detector potential will be made by the Contracting Officer to determine suitability of the detector. The inspection for holidays shall be performed just before covering the pipe with backfill and every precaution shall be taken during backfill to prevent damage to the protective covering. Equipment and labor necessary for inspection shall be furnished by the Contractor.

3.6.4 Installing Buried Piping

Pipe and accessories shall be handled carefully to assure a sound, undamaged condition. Care shall be taken not to damage coating when lowering pipe into a trench and when backfilling. Nonmetallic pipe shall be installed in accordance with pipe manufacturer's instructions. Underground pipelines shall be laid with a minimum pitch of 25 mm per 15 m 1 inch per 50 feet. Horizontal sections shall have a minimum coverage of 450 mm 18 inches. Piping shall be free of traps and shall drain toward tank. The full length of each section of underground pipe shall rest solidly on the pipe bed. Piping connections to equipment shall be as indicated, or as required, by the equipment manufacturer. Tank connections shall be made with two elbow swing joints [or flexible connectors] to allow for differential settlement. The interior of the pipe shall be thoroughly cleaned of all foreign matter before being lowered into the trench and shall be kept clean during installation. The pipe shall not be laid in water or when the trench or weather conditions are unsuitable. When work is not in progress, open ends of pipe and fittings shall be securely closed so that water, earth, or other substances cannot enter the pipe or fittings. Any pipe, fittings, or appurtenances found defective after installation shall be replaced. Threaded joints shall be made with tapered threads and shall be made perfectly tight with joint compound applied to the male threads only. This requirement shall not apply for the gauging hatch or similar connections directly over the tank where the line terminates in a fitting within a cast-iron manhole designed to allow for differential setting. Where steel piping is to be anchored, the pipe shall be welded to the structural steel member of the anchor and the abraded area shall be patched with protective coating or covering as specified. Piping passing through concrete or masonry construction shall be fitted with sleeves. Each sleeve shall be of sufficient length to pass through the entire thickness of the associated structural member and shall be large enough to provide a minimum clear distance of 13 mm 1/2 inch between the pipe and sleeve, except where otherwise indicated. Sleeves through concrete may be 0.912 mm 20 gauge metal, fiber, or other approved material. Sleeves shall be accurately located on center with the piping and shall be securely fastened in place. The space between the sleeves and the pipe shall be caulked and filled with bituminous plastic cement or mechanical caulking units designed for such use.

3.6.5 Fiberglass Reinforced Plastic (FRP) Pipe

Field assembly of the pipe shall be done in conformance with the manufacturer's written instructions and installation procedures. Several pipe joints having interference-fit type couplings may be field-bonded and cured simultaneously. However, the pipe shall not be moved nor shall additional joints be made until the previously laid joints are completely cured. Joints not having interference-fit type couplings shall be fitted with a clamp which shall hold the joint rigidly in place until the joint cement has completely cured. The clamps shall have a protective material on the inner surface to prevent damage to the plastic pipe when the clamp is tightened in place. The pipe shall be provided with a device or method to determine when the joint is pulled against the pipe stop. A gauge provided by the pipe manufacturer shall be used to measure the diameter of the spigot ends to insure the diameter conforms to the tolerances specified by the manufacturer. All pipe ends shall be gauged. FRP pipe shall be utilized for buried piping only. No aboveground FRP pipe is allowed. Cutting shall be done with a hacksaw or circular saw with an abrasive cutting wheel.

3.6.5.1 Installation

Pipe shall be buried to the elevation shown on the profiles, except that in no case shall pipe under roadways be buried less than 900 mm 36 inches. Backfill shall not include large or sharp-edged rocks of any size in direct contact with the pipe surfaces. Compacting shall be done so as to avoid damage to the pipeline. Conduits or sleeves of steel pipe at least 50 mm 2 inches in diameter larger than the FRP pipe size shall be provided under heavy traffic roadways. Bending of pipe to follow ditch contours shall be limited to long trench curvatures and will not be permitted for abrupt changes in pipe direction. Bend radii shall not be less than shown in the manufacturer's installation procedures.

3.6.5.2 Thrust Blocks

Concrete thrust blocks shall be provided at all tees, valves, blind flanges, reducers, or whenever the pipe alignment changes direction. They shall be sized in accordance with the pipe manufacturer's instructions to suit local soil conditions, operating pressures, test pressures, pipe size, and thermal conditions. In case of a conflict, the most stringent requirements shall govern.

3.6.5.3 Curing of Field-Bonded Joints

All field-bonded epoxy-cemented joints, regardless of ambient temperatures, shall be cured with a self-regulating, thermostatically controlled electrical heating blanket for the time and temperature recommended by the manufacturer for the applicable size and type of joint, or by an alternate approved heating method. The joined sections shall not be moved during heating or before the joint has cooled to 27 degrees C 80 degrees F or to ambient temperature, whichever is higher.

3.6.5.4 Metal to FRP Connections

Metal to FRP connections shall be made with flanged connections. Steel flanges for bolting to FRP flanges shall be flat-faced type. Where raised-face steel flanges are used, spacer rings shall be utilized to provide a flat-face seat for FRP flanges. A full-face Buna-N gasket, 3.2 mm 1/8 inch thick with a shore hardness of 50 to 60, shall be used between all flanged connections. The FRP flange shall have raised sealing rings. Flat washers shall be used under all nuts and bolts on FRP flanges. Bolts and nuts shall be of noncorrosive metal and torqued to not more than 135 newton meters 100 ft-lbs. Flanges shall not be buried. A concrete pit shall be provided for all flanged connections.

3.6.6 Buried Fuel Piping

Buried fuel piping shall be in accordance with Section 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS.

3.7 CATHODIC PROTECTION

Cathodic protection shall be in accordance with Section 33 56 10 FACTORY-FABRICATED FUEL STORAGE TANKS.

3.8 FIELD PAINTING

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NOTE: Where identification of piping is required by the using service, this paragraph will be amplified to include appropriate requirements either directly or by reference to a separate section. Air Force requirements are covered in AFM 88-15.
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All ferrous metals not specified to be coated at the factory shall be cleaned, prepared, and painted as specified in Section 09 90 00 PAINTS AND COATINGS. Exposed pipe covering shall be painted as specified in Section 09 90 00 PAINTS AND COATINGS. Aluminum sheath over insulation shall not be painted.

3.9 CLEANING OF BOILERS AND PIPING FOR TESTING

3.9.1 Boiler Cleaning

After the hydrostatic tests but before the operating tests, the boilers shall be cleaned of foreign materials. Wherever possible, surfaces in contact with water shall be wire-brushed to remove loose material. The Contractor may use the following procedure or may submit his own standard procedure for review and approval by the Contracting Officer. Boilers shall be filled with a solution consisting of the following proportional ingredients for every 3785 liters 1000 gallons of water and operated at approximately 207 to 350 kPa 30 to 50 psig for a period of 24 to 48 hours, exhausting steam to the atmosphere:

11 kg 24 pounds caustic soda	3.6 kg 8 pounds sodium nitrate
11 kg 24 pounds disodium phosphate, anhydrous agent	230 mg 1/2 pound approved wetting

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

3.9.2 Boiler Water Conditioning

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 but for at least 30 days of operation. Approved chemicals and method of treatment shall be used.

TABLE I. PIPE

Service	Pressure, kPa psig	Material	Specification	Type
Steam	0-35000-500	Std. wt. black steel	ASTM A53/A53M	Type E, Grade A

TABLE I. PIPE				
Service	Pressure, kPa psig	Material	Specification	Type
Condensate return	0-17000-250	Extra strong black steel	ASTM A53/A53M	Type E, Grade A
		Copper pipe	ASTM B42	[_____]
Boiler feed & blowoff lines	0-41000-600	Extra strong black steel (2)	ASTM A53/A53M	Type E, Grade A
Feedwater piping	0-8600-125	Std weight black steel	ASTM A53/A53M	Type E, Grade A
Water column (1)	0-41000-600	Std weight black steel (2)	ASTM A53/A53M	Type E, Grade A
Vent & exhaust pipe	0-1700-25	Std weight black steel	ASTM A53/A53M	Type E, Grade A
Compressed air	0-8600-125	Std weight black steel	ASTM A53/A53M	Type E, Grade A
Gauge piping	0-1700-25	Copper tubing	ASTM B88MASTM B88	Type K or L
		Blask steel (2)	ASTM A53/A53M	Type E, Grade A
Fuel oil (No. 2)	0-10000-150	Copper tubing	ASTM B88MASTM B88	Type K or L
		Fiber reinforced plastic (FRP) (buried service only)	API Spec 15LR	[_____]
Fuel oil (Nos. 4, 5 & 6)	0-10000-150	Std weight black steel	ASTM A53/A53M	Type E, Grade A
Control air	0-10000-150	Copper tubing	ASTM B68/B68M	[_____]
		Std weight black steel	ASTM A53/A53M	Type E, Grade A
Note 1: No bending of pipe will be permitted. Crosses with pipe plugs at connections shall be provided.				
Note 2: Extra strong (XS) minimum weight. Conform to ASME B31.1 for wall thickness.				

TABLE II. FITTINGS				
Service	Size, mm inches	Title	Materials	Specification
Steam (1)	Under 80 mm 3 inches	Threaded	Malleable-iron	ASME B16.3
	Under 80 mm 3 inches	Threaded	Steel	ASME B16.11
	80 mm 3 inches and larger	Flanged	Steel	ASME B16.5
	80 mm or larger	Buttwelded	Steel	ASME B16.9

TABLE II. FITTINGS				
Service	Size, mm inches	Title	Materials	Specification
Condensate return	Under 80 mm 3 inches	Threaded	Cast-iron	ASME B16.4 Black, Class 250
	Under 80 mm 3 inches	Threaded	Malleable-iron	ASME B16.3, Class 300
	Under 80 mm 3 inches	Threaded	Bronze	ASME B16.15
	80 mm 3 inches and larger	Buttwelded	Steel	ASME B16.9
Vent pipe	Under 80 mm 3 inches	Threaded	Malleable-iron	ASME B16.3
	80 mm or larger	Buttwelded	Steel	ASME B16.9
Exhaust pipe	Under 80 mm 3 inches	Threaded	Zinc-coated malleable-iron	ASME B16.3
	80 mm 3 inches and larger	Buttwelded	Steel	ASME B16.9
Boiler feed (2)	Under 80 mm 3 inches	Threaded	Malleable-iron	ASME B16.3
	80 mm 3 inches and larger	Buttwelded	Steel	ASME B16.9
Feedwater pipe	Under 80 mm 3 inches	Threaded	Malleable-iron	ASME B16.3
	80 mm 3 inches and larger	Buttwelded	Steel	ASME B16.9
Blowoff lines (2)	All	Buttwelded	Steel	ASME B16.9
		Socket welded	Steel	ASME B16.11
		Flanged with long radius elbows	Steel	ASME B16.5
Water column piping (2)	Under 80 mm 3 inches	Threaded	Malleable-iron	ASME B16.3
Fuel oil	All	Threaded	Malleable-iron	ASME B16.3
		Flared or brazed	Cast or wrought bronze	ASME B16.18 ASME B16.26
		Plastic	FRP	Compatible with pipe API Spec 15LR
Gauge pipe	All	Flared or soldered	Cast or wrought bronze	ASME B16.18 ASME B16.26
Note 1: Conform to ASME B31.1 for wall thickness. Match requirements for steam piping.				
Note 2: Conform to ASME B31.1 for wall thickness, except minimum shall be extra strong pipe. Match piping requirements.				

3.10 MANUFACTURERS' FIELD SERVICES

Provide the services of a manufacturer's representative who is experienced

in the installation, adjustment, and operation of the equipment specified. The representative shall supervise the installing, adjusting, and testing of the equipment.

3.11 FIELD TRAINING

Provide a field training course for designated operating staff members. Training shall be provided for a total period of [_____] hours of normal working time and shall start after the system is functionally complete, but prior to final acceptance tests. Field training shall cover all of the items contained in the approved operating and maintenance instructions as well as demonstrations of routine maintenance operations. Contracting Officer shall be notified at least 14 days prior to date of proposed conduction of the training course.

3.12 FRAMED INSTRUCTIONS

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

3.13 TESTS

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NOTE: Before occupancy of a facility the boilers shall be inspected in accordance with the Code of Boiler and Pressure Vessel Inspectors (BPVI) and the American Society of Mechanical Engineers (ASME). Inspectors must be certified in accordance with BPVI standards.

References to inapplicable types of boilers will be deleted.

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Submit test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Each test report shall indicate the final position of controls. Submit a written statement from the manufacturer's representative certifying that combustion control equipment has been properly installed and is in proper operating condition, upon completion of the installation. The action settings for all automatic controls in the form of a typed, tabulated list indicating the type of control, location, setting, and function.

3.13.1 Hydrostatic Tests

Following erection, each boiler shall be tested hydrostatically and proved tight under a gauge pressure of 1-1/2 times the working pressure specified. Following the installation of piping and boiler house equipment, but before the application of any insulation, hydrostatic tests shall be made and the system proved tight under gauge pressures of 1-1/2

times the specified working pressure. The boilers shall be tested and the piping connections inspected by a NBBI-commissioned boiler inspector for determining compliance with all requirements in ASME BPVC SEC VIII D1 and the Contracting Officer shall be supplied with a certificate of approval for each boiler. After flushing and operationally testing, underground portions of oil containing piping systems shall be leak tested. The test shall be the [standpipe method][buoyancy device] type and shall conform to the requirements in NFPA 329. The test method shall not involve pressurization of the system in any way which could increase the rate of product escape through an established leak.

3.13.2 Efficiency and Operating Tests

Upon completion of installation, the boiler plant shall be subjected to operating tests required to demonstrate satisfactory functional operation. Adjust equipment and controls before the scheduled operating test. A testing schedule shall be submitted to the Contracting Officer at least 15 days before the scheduled test. Each operating test shall be conducted as directed by Contracting Officer.

a. An efficiency and capacity test shall be run on one boiler of each size installed, conducted in accordance with ASME PTC 4 abbreviated efficiency test utilizing the heat loss method, except for use of measuring or metering devices properly calibrated before the test, for the purpose of metering the water used and weighing the amount of fuel burned. Water meter used in the test shall be suitable for hot water. Instruments, test equipment, and test personnel required to properly conduct tests shall be provided by the Contractor. The necessary fuel, water, and electricity will be furnished by the Government.

b. The performance tests shall, in each case, cover the periods for the capacities tabulated below:

	Percent of Capacity	
Time (Minimum)	Waterwall and Watertube Boilers	Firetube and Boilers
First 1 hour	50	50
Next 1 hour	75	75
Next 4 hours*	100	100
Next 2 hours	110	
*The efficiency tests may be conducted either concurrently with the operating tests or separately, at the option of the Contractor. Efficiency shall be not less than specified. Maximum moisture content of saturated steam leaving the boiler shall be as specified.		

c. The efficiency and general performance tests on the boilers shall be conducted by a qualified test engineer, and observed by the Contracting Officer. All testing apparatus shall be set up, calibrated, tested, and ready for testing the boiler before the arrival of the Contracting Officer.

d. Calibration curves or test results furnished by an independent testing laboratory of each instrument, meter, gauge, and thermometer to be used in efficiency and capacity tests shall be furnished before the test. A test report including logs, heat-balance calculations, and tabulated results together with conclusions shall be delivered in quadruplicate. An analysis of the fuel being burned on the test shall be submitted to the Contracting Officer.

e. The analysis shall include all pertinent data tabulated in the ASME PTC 4 abbreviated efficiency test. Necessary temporary test piping not less than 100 mm 4 inches in diameter and steam silencer to exhaust excess steam to atmosphere, in the event the boiler load is insufficient to meet the capacity specified, shall be provided. Control valve for exhausting excess steam to atmosphere shall be provided in a convenient location inside the boiler room. Instruments required for conducting the boiler tests are contained in ASME PTC 19.11.

3.13.3 Test of Fuel Burning Equipment

Test of fuel burning equipment shall demonstrate that equipment installed will meet the requirements of the specifications. Oil burners shall meet the test requirements of UL 296. The accuracy range and smoothness of operation of the combustion controls shall be demonstrated by varying the demand throughout the entire firing range required by the turndown ratio specified for the [burner][and][stoker] and, in the case of automatic sequenced burners, by further varying the firing rate to require on-off cycling. The control accuracy shall be as specified. The specified turndown ratio shall be verified by firing at the minimum firing rate. The operation of the flame safeguard control shall be verified by simulated flame and ignition failures.

3.13.4 Test of Deaerating Feedwater Heater

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

3.13.5 Test of Water Treatment Equipment

Test of water treatment equipment shall meet the requirements specified as to capacity and quality of effluent. Tests for ion-exchange units shall cover at least two complete regenerations and capacity runs.

3.13.6 Test for Steam Purity and Water Level Stability

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

[3.13.6.1 Conductivity Tests for Boilers without Superheaters

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NOTE: Delete the inapplicable paragraph.
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Steam tests for boilers without superheaters, not used for power

generation or large turbine drive, shall be made on steam sampled in accordance with ASTM D1066. The conductivity of the steam corrected for carbon dioxide and ammonia content shall not exceed 30 microhms at 18 degrees C65 degrees F.

]3.13.6.2 Conductivity Test, Boilers with or without Superheaters

The steam for boilers, with or without superheat, used for power generation or turbine drive for air-conditioning equipment shall be sampled in accordance with ASTM D1066 with the conductivity of the steam corrected for carbon dioxide and ammonia content not to exceed 4.0 microhms at 18 degrees C65 degrees F.

3.13.6.3 Water Level Stability Test

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

-- End of Section --