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USACE / NAVFAC / AFCESA **UFGS-15555A (February 2002)**
Preparing Activity: USACE **Superseding UFGS-15555A (May 2001)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 25 June 2004

Latest change indicated by CHG tags
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DIVISION 15 - MECHANICAL

SECTION 15555A

CENTRAL HIGH TEMPERATURE WATER (HTW) GENERATING PLANT AND AUXILIARIES

02/02

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SECTION 15555A

CENTRAL HIGH TEMPERATURE WATER (HTW) GENERATING PLANT AND AUXILIARIES
02/02

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NOTE: This guide specification covers the requirements for high temperature water plants of capacities over 2,930 kW (10,000,000 Btuh), producing water at temperatures of 115 to 227 degrees C (240 to 440 degrees F) at pressures up to 2.8 MPa (400 psig).

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.
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PART 1 GENERAL

1.1 REFERENCES

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NOTE: Issue (date) of references included in project specifications need not be more current than provided by the latest guide specification. Use of SpecsIntact automated reference checking is recommended for projects based on older guide specifications.
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The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL(AMCA)

AMCA 801	(2001) Industrial Process/Power Generation Fans: Specification Guidelines

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 11	(1990; R 1999) Load Ratings and Fatigue Life for Roller Bearings
ABMA 9	(1990; R 2000) Load Ratings and Fatigue Life for Ball Bearings

AMERICAN BOILER MANUFACTURERS ASSOCIATION (ABMA)

ABMA 202	(1983) Recommended Design Guidelines for Stoker Firing of Bituminous Coal

AMERICAN GAS ASSOCIATION (AGA)

AGA XR0104	(2001) AGA Plastic Pipe Manual for Gas Service

AMERICAN GEAR MANUFACTURERS ASSOCIATION (AGMA)

AGMA 6010	(1997; Rev F) Standard for Spur, Helical, Herringbone, and Bevel Enclosed Drives

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z21.22	(1999; A 2001) Relief Valves for Hot Water Supply Systems
ANSI Z83.6	(1990; A 1993) Gas-Fired Infrared Heaters

AMERICAN PETROLEUM INSTITUTE (API)

API Std 610	(2003) Centrifugal Pumps for Petroleum, Petrochemical, and Natural Gas Industries

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE-OF-WAY ASSOCIATION (AREMA)

AREMA Manual	(2003) Manual for Railway Engineering

AMERICAN WATER WORKS ASSOCIATION(AWWA)

AWWA C203	(2002; A C203a-99) Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot-Applied
AWWA C213	(2001) Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines

ASME INTERNATIONAL (ASME)

ASME B1.20.1	(1983; R 2001) Pipe Threads, General Purpose, Inch
ASME B16.11	(2002) Forged Fittings, Socket-Welding and Threaded
ASME B16.18	(2002) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.21	(1992) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.26	(1988) Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B16.3	(1998) Malleable Iron Threaded Fittings
ASME B16.34	(1996) Valves Flanged, Threaded, and Welding End
ASME B16.39	(1998) Malleable Iron Threaded Pipe Unions
ASME B16.5	(1996) Pipe Flanges and Flanged Fittings
ASME B16.9	(2001) Factory-Made Wrought Steel Buttwelding Fittings
ASME B19.3	(1991) Safety Standard for Compressors for Process Industries
ASME B31.1	(2001) Power Piping
ASME BPVC SEC I	(2001) Boiler and Pressure Vessel Code; Section I, Power Boilers
ASME BPVC SEC IX	(2001) Boiler and Pressure Vessel Code; Section IX, Welding and Brazing Qualifications
ASME BPVC SEC VII	(2001) Boiler and Pressure Vessel Code; Section VII, Recommended Guidelines for the Care of Power Boilers
ASME BPVC SEC VIII D1	(2001) Boiler and Pressure Vessel Code; Section VIII, Pressure Vessels Division 1 - Basic Coverage
ASME CSD-1	(2002) Control and Safety Devices for Automatically Fired Boilers
ASME PTC 10	(1997) Test Code on Compressors and Exhausters
ASME PTC 4.1	(1964; Addenda: 1968, 1969; R 1991) Steam Generating Units

ASTM INTERNATIONAL (ASTM)

ASTM A 106	(2002a) Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A 167	(1999) Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A 242/A 242M	(2003a) High-Strength Low-Alloy Structural Steel
ASTM A 36/A 36M	(2003a) Carbon Structural Steel
ASTM A 366/A 366M	(1997e1) Commercial Steel, Sheet, Carbon,(0.15 Maximum Percent Cold-Rolled**
ASTM A 514/A 514M	(2000a) High-Yield-Strength, Quenched and Tempered Alloy Steel Plate, Suitable for Welding
ASTM A 53/A 53M	(2002) Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A 568/A 568M	(2003) Steel, Sheet, Carbon, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for
ASTM A 653/A 653M	(2003) Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A 733	(2003) Welded and Seamless Carbon Steel and Austenitic Stainless Steel Pipe Nipples
ASTM B 68	(2002) Seamless Copper Tube, Bright Annealed
ASTM B 68M	(1999) Seamless Copper Tube, Bright Annealed (Metric)
ASTM B 88	(2002) Seamless Copper Water Tube
ASTM B 88M	(1999) Seamless Copper Water Tube (Metric)
ASTM C 155	(1997; R 2002) Insulating Firebrick
ASTM C 27	(1998; R 2002) Fireclay and High-Alumina Refractory Brick
ASTM C 34	(1996; R 2001) Structural Clay Load-Bearing Wall Tile
ASTM C 401	(1991; R 2000) Alumina and Alumina-Silicate Castable Refractories
ASTM C 62	(2001) Building Brick (Solid Masonry Units Made from Clay or Shale)

ASTM D 396	(2002a) Fuel Oils
ASTM G 21	(1996; R 2002) Determining Resistance of Synthetic Polymeric Materials to Fungi

CONVEYOR EQUIPMENT MANUFACTURERS ASSOCIATION (CEMA)

CEMA B105.1	(1992) Welded Steel Conveyor Pulleys with Compression Type Hubs
CEMA Belt Book	(1998) Belt Conveyors for Bulk Materials

EXPANSION JOINT MANUFACTURERS ASSOCIATION (EJMA)

EJMA Stds	(2003) EJMA Standards

HYDRAULIC INSTITUTE (HI)

HI 1.1-1.5	(1994) Centrifugal Nomenclature

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C37.90	(1989) Relays and Relay Systems Associated with Electric Power Apparatus

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-58	(2002) Pipe Hangers and Supports - Materials, Design and Manufacture
MSS SP-69	(2002) Pipe Hangers and Supports - Selection and Application
MSS SP-70	(1998) Cast Iron Gate Valves, Flanged and Threaded Ends
MSS SP-71	(1997) Gray Iron Swing Check Valves, Flanged and Threaded Ends
MSS SP-80	(2003) Bronze Gate, Globe, Angle and Check Valves
MSS SP-85	(2002) Cast Iron Globe & Angle Valves, Flanged and Threaded Ends

NACE INTERNATIONAL (NACE)

NACE RP0185	(1996) Extruded, Polyolefin Resin Coating Systems with Soft Adhesives for Underground or Submerged Pipe

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 1	(2000) Industrial Control and Systems: General Requirements

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2002) National Electrical Code
NFPA 8501	(1997) Single Burner Boiler Operation

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

NIST HB 44	(2004) NIST Handbook 44: Specifications, Tolerances, and other Technical Requirements for Weighing and Measuring Devices

RUBBER MANUFACTURERS ASSOCIATION (RMA)

RMA IP-1	(1989) Conveyor and Elevator Belt Handbook

THE SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC Paint 16	(1982; R 2000) Coal Tar Epoxy-Polyamide Black (or Dark Red) Paint
SSPC SP 6	(2000) Commercial Blast Cleaning

TUBULAR EXCHANGER MANUFACTURERS ASSOCIATION (TEMA)

TEMA Stds	(1999) Standards of the Tubular Exchange Manufacturers Association (TEMA)

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-1509	(Basic; Notice 1) Clock, Wall; Electric Synchronous Motor

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	(2003; Rev thru Jan 2004) Oil Burners
UL 726	(1995; Rev thru Jan 2001) Oil-Fired Boiler Assemblies
UL 795	(1999) Commercial-Industrial Gas Heating Equipment

1.2 GENERAL REQUIREMENTS

1.2.1 Standard Products

Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products and shall 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.

1.2.2 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.

1.2.3 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). 1 mil.

1.2.4 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 05500A MISCELLANEOUS METAL.

1.2.5 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.

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[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 "Material Safety Sheet" (Form OSHA-20), completed by the asbestos manufacturer, stating that the product is not an asbestos health hazard.]

1.3 SUBMITTALS

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NOTE: Submittals must be limited to those necessary for adequate quality control. The importance of an

item in the project should be one of the primary factors in determining if a submittal for the item should be required.

A "G" following a submittal item indicates that the submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation 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 projects.

Submittal items not designated with a "G" are considered as being for information only for Army projects and for Contractor Quality Control approval for Navy projects.
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Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.][for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with Section 01330 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

High Temperature Water Generators

Detail drawings consisting of schedules, performance charts, brochures, diagrams, drawings, and instructions necessary for installation of the HTW generating units and associated equipment, and for piping, wiring, devices, trenches, and related foundations. Complete setting plans certified by the HTW generator and burner manufacturers. Detail drawings for HTW generators and appurtenances, including coal and ash handling equipment. Drawings shall indicate clearances required for maintenance and operation and shall 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. Detailed drawings of pipe anchors, before installation. Manufacturer's written instructions indicating optimum pressure at all manometer connectors shall be included.

SD-03 Product Data

Calculations

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

Spare Parts

Spare parts data for each item of equipment provided, after approval of the drawings and not later than [_____] months before the date of beneficial occupancy. The data shall include 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] year[s] of service.

Manufacturer's Instructions

Proposed diagrams, instructions, and other sheets, before posting. Framed instructions under glass or in laminated plastic, including wiring and control diagrams showing the complete layout of the entire system, shall be posted 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.

Performance Tests

A proposed performance test procedure for required tests, 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. The Contractor's complete plan for water treatment, including proposed chemicals to be used and nationally recognized testing codes applicable to the system, prior to system startup.

Welding Qualifications

A copy of qualified welding procedures and a list of names and identification symbols of qualified welders and welding operators.

Field Training

Proposed schedule for field training, at least 2 weeks prior to the start of related training.

SD-06 Test Reports

Tests

Test reports shall be submitted 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. The action settings for all automatic controls in the form of a typed, tabulated list indicating the type of control, location setting, and function shall be included. 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.

SD-10 Operation and Maintenance Data

High Temperature Water Generators

Operating instructions, prior to the field training course. [Six] [_____] copies of operating instructions 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. Maintenance instructions, prior to the field training course. [Six] [_____] complete copies of maintenance instructions 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.

1.4 WELDING QUALIFICATIONS

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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 the welding submittal.

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[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 05090A WELDING, STRUCTURAL.] [Welding and nondestructive testing procedures are specified in Section 05093 WELDING PRESSURE PIPING.]

1.5 DELIVERY AND STORAGE

All equipment delivered and placed in storage shall be stored with protection from the weather, humidity and temperature variation, dirt and dust, or other contaminants.

1.6 VERIFICATION OF DIMENSIONS

The Contractor shall become familiar with all details of the work, verify all dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing the work.

PART 2 PRODUCTS

2.1 HIGH TEMPERATURE WATER GENERATORS

Each HTW generator (boiler) shall have the capacity indicated when operating with [_____] degrees C ([_____] degrees F) [_____] degrees F entering water temperature and [_____] degrees C ([_____] degrees F) [_____] degrees F outlet temperature with a water flow of [_____] kg per second ([_____] pounds per hour). ([_____] pounds per hour). The HTW generators shall be designed for a maximum allowable working pressure of [_____] kPa ([_____] psig) [_____] psig at [_____] degrees C ([_____] degrees F). [_____] degrees F. The equipment design and accessory locations shall permit accessibility for maintenance and service. Design conditions shall be as follows:

a. Site elevation, [_____] m ([_____] feet). [_____] feet.

b. Ambient air temperatures, [_____] degrees C ([_____] degrees F) [_____] degrees F to [_____] degrees C ([_____] degrees F). [_____] degrees F.

c. Reference air temperature, 27 degrees C (80 degrees F). 80 degrees F.

The HTW generators shall be capable of operating continuously at maximum specified capacity without damage or deterioration to the generator, its setting, or firing equipment or auxiliaries. The generator shall be operable automatically while burning the fuel specified. The HTW generators shall operate on [coal meeting the requirement of paragraph FUEL BURNING EQUIPMENT] [fuel oil conforming to grade number of ASTM D 396] [a combination of coal and fuel oil conforming to ASTM D 396].

2.1.1 Capacity

Rated capacity shall be the capacity at which the HTW generators will operate continuously without exceeding the furnace heat release, volumetric and radiant, furnace exit temperature, and gas exit temperature specified. Generator auxiliaries including fans, motors, drives, and similar equipment shall be provided with at least 10 percent excess capacity to allow for field variations in settings and to compensate for any unforeseen increases in pressure losses in appurtenant piping and ductwork.

2.1.2 Electrical Equipment

Electric motor-driven equipment shall be provided complete with motors and necessary motor control devices. Motors and motor control devices shall be as specified in Section 16415A ELECTRICAL WORK, INTERIOR including requirements for hazardous area locations. Motors shall have electrical characteristics and enclosure type as shown. Unless otherwise indicated, motors of 1 hp and above shall be high efficiency type.

2.1.2.1 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.

2.1.2.2 Motor Starters

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

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Where a motor starter is not indicated in a motor control center on the electrical drawings, a motor starter shall be provided under this section of the specifications. 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. Manual or automatic control and protective or signal devices required for the operation specified, and any wiring required to such devices, shall be provided whether indicated or not. Where two-speed or variable-speed motors are indicated, solid-state variable-speed controllers may be provided to accomplish the same function.

2.1.3 Heating Plant Requirements

The plant shall include [package type] [field-erected type], [coal-] [fuel oil-] [combination coal/fuel oil-] fired, controlled circulation, HTW generators; expansion vessels; nitrogen pressurization system; makeup water equipment; fuel systems; pumps; and all controls, piping, insulation, miscellaneous plant equipment and other accessories indicated or necessary to provide a complete and operable system.

2.1.4 HTW Generator Design Requirements

2.1.4.1 Radiant Heat Input

The radiant heat input for the effective radiant heating surface of controlled circulation watertube HTW generators shall be limited to a maximum of 394 kW per square meter (125,000 Btuh per square foot). 125,000 Btuh per square foot.

2.1.4.2 Maximum Heat Input

The maximum heat input per cubic meter (cubic foot) cubic foot of furnace volume shall be limited to 931 MJ per cubic meter (25,000 Btuh per cubic foot) 25,000 Btu per cubic foot with spreader stokers and watertube boilers and 1,677 MJ per cubic meter (45,000 Btuh per cubic foot) 45,000 Btuh per cubic foot with underfeed stokers.

2.1.4.3 Combustion Gas Temperature

The combustion gas temperature at the furnace exit shall be a [minimum of 56 degrees C (100 degrees F) 100 degrees F less than the ash fusion softening temperature (reducing atmosphere) of the coal specified] [or] [maximum of 1150 degrees C (2100 degrees F) 2100 degrees F when furnace is oil-fired].

2.1.4.4 Design Requirements

The HTW generator shall be of the controlled, forced-circulation, watertube, once-through type designed and constructed for high temperature water service, and shall be so certified by the manufacturer. Except as modified, the design shall conform to the applicable construction and performance requirements of ASME BPVC SEC I and ASME BPVC SEC VII with the following additional requirements:

a. The water pressure drop through the generator shall not exceed 105 kPa (15 psig) 15 psi based on a water temperature differential of 83 degrees C (150 degrees F), 150 degrees F, generator inlet to outlet.

b. The generator shall not have steam space or other spaces where steam can be trapped. Headers shall be vented at high points as required.

c. Tubes and headers located in any radiant heat transfer zone shall be designed for horizontal flow or upflow of water.

d. Tubes and headers located outside the primary radiant heat transfer zones may be designed for downflow of water.

e. The generator shall be designed for equalization of water flow through the tube circuits. Radiant and convective heating surfaces shall be arranged for series water flow to insure uniform flow distribution and temperature rise. Flow shall be proportioned to the heat input to prevent formation of steam in any tubes or headers to the extent that flow distribution becomes unbalanced. Distribution of flow may be controlled by limiting the number of flow paths in parallel, or by using restrictors (orifices), when required, in each group of parallel flow paths to increase pressure drop and to insure that all groups have the same pressure drop.

2.1.4.5 Spreader Stoker Units

Spreader stoker units with continuous or intermittent automatic mechanical ash discharge grates shall have a maximum loading of 2206 kW per square meter (700,000 Btuh per square foot) 700,000 Btuh per square foot of grate area. The traveling grate type shall have a maximum loading of 1,419 kW per square meter (450,000 Btuh per square foot) 450,000 Btuh per square foot of grate area.

2.1.4.6 Underfeed Dumping Grate Units

Underfeed dumping grate units shall have a maximum loading per square meter (square foot) square foot of grate of 1,419 kW (450,000 Btuh), 450,000 Btuh, assuming a 10 percent maximum ash content and 1200 degrees C (2200 degrees F) 2200 degrees F minimum ash softening temperature. The area shall not include side dumping areas.

2.1.4.7 Effective Radiant Heating Surface

Effective radiant heating surface is defined as the heat exchange surface within the furnace boundaries which is directly exposed to radiant heat of the flame on one side and to the medium being heated on the other. This surface includes plain or finned tubes and headers and plain surfaces which may be bare, metal covered, or metallic core covered. Refractory lined surfaces shall not be counted. The surface shall be measured on the side receiving heat. Computations of effective radiant heating surfaces shall be based on the following:

a. Bare, metal covered, or metallic core covered tubes and headers - the projected area, external diameter times length, of the tube or header.

b. Extended surfaces, metal and metallic surfaces extending from the tubes or headers - 80 percent of the flat projected area, except metal blocks not integral with tubes or headers; extended surfaces less than 6.4 mm (1/4 inch) 1/4 inch thick or more than 32 mm (1-1/4 inches) 1-1/4 inches long; that portion of the extended surface which is more than one tube or header radius from the tube or header from which it extends, are not included.

c. Furnace exit tubes - the projected area of those portions of the first two rows of exit tubes receiving radiant heat from the fire.

2.1.4.8 Furnace Volume

Furnace volume 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.

2.1.4.9 Burners

Burners shall conform to requirements of NFPA 8501, UL 296, and UL 726, except as otherwise specified. Flame safeguard controls shall be equipped with repetitive self-checking circuits.

2.1.4.10 Generator

The HTW generator shall have the continuous capacity within the specified range at the specified pressure with boiler feed water at approximately [_____] degrees C ([_____] degrees F). [_____] degrees F. The flue gas outlet temperature shall be [_____] degrees C ([_____] degrees F), [_____] degrees F, based on excess air of [_____] percent and carbon loss of [_____] percent, at all loads above 50 percent of maximum continuous capacity. Output capacity shall be based on tests of the HTW generator [and burner] as a unit.

2.1.4.11 Nameplates

Each HTW generator shall have nameplates stamped with:

a. Maximum continuous capacity in Watts (Btuh). Btuh.

b. Radiant heating surface in square meters (square feet). sq. ft.

c. Total heating surface in square meters (square feet). sq. ft.

d. Design pressure in Pa (psig). psig.

2.2 HIGH TEMPERATURE WATER GENERATOR DETAILS

Mercury shall not be used in thermometers.

2.2.1 HTW Generators and Components

HTW generators shall be [site assembled] [shop assembled] type and arranged to suit firing equipment as specified. The HTW generators shall be designed for continuous operation at the capacity indicated. Unit shall be designed to burn [fuel oil specified] [and] [coal of size and analysis specified]. Watertube, waterwall type HTW generating units shall be furnished complete with [oil burners] [and] [stokers for coal firing], forced and induced draft fans, control and instrument panel with limit and automatic controls, soot blowers, [over fire air system,] feedwater regulator, low water flow cutoff and alarm, feed piping, and all other fittings, auxiliaries, and appurtenances necessary for safe and efficient operation. Firing equipment and boiler shall be matched and adjusted in accordance with the boiler manufacturer's requirements. [The HTW generator shall be factory-fabricated and assembled on a steel foundation or foundations, or shipped in not more than three complete subunits to minimize field erection.] Combustion controls shall be provided.

2.2.1.1 Headers

Boiler shall be header-and-tube construction with header diameter limited to accommodate the water flow and required distribution with a reasonable pressure drop. The use of drums or excessive header sizes will not be acceptable. Headers shall be seamless steel ASTM A 106, Grade B. Headers shall not be located in primary radiant furnace section. Bottom portion of header at tube connection shall not be insulated. Method of tube attachment to headers shall be by strength welding or by rolling, seal welding, and rerolling in accordance with ASME BPVC SEC I. Rolling of tubes into headers only is not acceptable.

2.2.1.2 Tubes

Tubes shall be electric welded or seamless steel. Boilers shall have water-cooled furnace walls of a design suitable for the application. Tubes located in the primary furnace shall be designed for horizontal or upflow of water. The water shall be distributed to the heating surface in proportion to the heat absorbing capacities of these surfaces. Tube heat absorbing surfaces shall be located so that radiant and convection sections provide for series flow of water, from generator inlet to outlet, to ensure uniform water distribution and uniform temperature rise from inlet to outlet. Where required, flow orifices shall be provided. Each orifice shall be protected from clogging by individual strainers or by the master strainer located in the HTW generator return line. If individual strainers are utilized, individual access openings for each strainer shall be provided. Access plugs, if used, shall be of the shoulder type with machined surface. The individual access openings shall be provided with stainless steel filled gaskets. All header gasket surfaces shall be machined to provide proper seating of gasket.

2.2.1.3 Baffles

Baffles shall be arranged to bring the products of combustion into contact with the heating surfaces. Baffles shall be either water-cooled or a refractory material or metal suitable for temperatures encountered. Steel plate or refractory baffles, if used, shall be provided with water cooling on the radiant heat (furnace) side. The generator's convection section shall have counterflow, water-to-gas, to provide an integral economizer arrangement for optimum heat absorption, gas-to-water. Draft loss shall be held to a minimum.

2.2.1.4   Furnace

Furnace shall be water-cooled and the combustion space shall be provided with water cooling on sidewalls, rear wall, roof, and front, except the portion of the front wall section required for [stoker installation] [and] [burner installation]. For stoker-fired generators, furnace side walls and rear wall shall be water-cooled by vertical tubes with center-to-center spacing not to exceed twice the tube diameter, and shall be furnished with cast-iron, water-cooled armor block at the grate line to a height of not less than 380 mm (15 inches) 15 inches above the grate line. The armor block shall be keyed and held in place without the use of bolts, pins, or mastic. The armor block shall be readily replaceable without the use of special tools.

2.2.1.5   Supports

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

2.2.1.6   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 temperature 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.

2.2.1.7   Miscellaneous

Pipe connections shall be provided for water inlet and drain outlet, drain valves, relief valves, blowoff, air supply to soot blowers, gauge and vent, chemical feed, and instruments. HTW generators shall be provided with necessary jets for furnace turbulence, the number and arrangement of which shall be as recommended by the HTW generator 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 high temperature roller or ball bearings at both ends of the shaft and shall have a suitable operating arm and rod.

2.2.2   HTW Generator Setting Materials

Materials shall conform to the following:

a. Firebrick: ASTM C 27, class shall be as recommended by the HTW generator manufacturer.

b. Insulating Brick: ASTM C 155, Class A.

c. Castable Refractory: ASTM C 401. The minimum modulus of rupture for transverse strength shall not be less than 4137 kPa (600 psi) 600 psi after being heat-soaked for 5 hours or more at a temperature in excess of 1370 degrees C (2500 degrees F). 2500 degrees F.

d. Mortar, Air-Setting, Refractory: As recommended by the HTW generator manufacturer.

e. Brick, Common: ASTM C 62.

f. Tile, Load-Bearing, Hollow: ASTM C 34, Grade LBX.

g. Iron and Steel Sheets: Galvanized, ASTM A 653/A 653M; gauge numbers specified refer to United States Standard gauge. Uncoated, black: ASTM A 568/A 568M, ASTM A 366/A 366M, or ASTM A 36/A 36M.

2.2.2.1 HTW Generator Casing

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NOTE: On water tube type HTW generators 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.

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[HTW generator walls shall be steel-encased wall construction with fabrication details as recommended by the HTW generator manufacturer. HTW generator wall and roof lining shall consist of a continuous screen of closely spaced water tubes. Casing for HTW generators shall be double wall construction. Reinforced, welded, gas-tight inner casing shall be constructed of not lighter than 3.416 mm (10 gauge) 10 gauge black steel sheets. Outer casing shall be constructed of not less than 1.897 mm (14 gauge) 14 gauge steel sheets. Outer casing may be either bolted or welded. Inner casing shall be reinforced with structural steel to provide rigidity and prevent buckling. Inner casing in furnace section shall abut furnace tubes with no foreign sealer between the tube steel and the casing steel. Casing shall not be attached to tubes. Each horizontal tube shall be supported independently of casing at intervals not exceeding 1.8 mm. 6 feet. The inner casing shall be applied so as to form expansion joints at the point of tube support. Where refractory is installed at access doors, the double casing shall be constructed to form a gas-tight seal and at no point shall combustion gases be able to enter between inner and outer casing. 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. Block insulation shall be applied between the inner and outer casings and held securely with insulating pins. The casing tested shall be capable of holding a pressure of 1-1/2 times the predicted maximum furnace operating pressure.] [HTW generator walls shall be of welded-wall construction. The width of the fins shall be limited to 19 mm (3/4 inch) 3/4 inch to prevent overheating of the fins under all operating conditions. Designs exceeding 19 mm (3/4 inch) 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) 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 1-1/2 times the predicted maximum furnace operating pressure.]

2.2.2.2 Walls

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NOTE: For personnel safety, the design temperature of the casing surface should not exceed 65 degrees C (150 degrees F). Should the designer wish to use a design surface temperature between 55 and 65 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.

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[Refractory behind the waterwall tubes shall be high-duty refractory not less than 65 mm 2-1/2 inches thick conforming to manufacturer's requirements.] High temperature block and mineral wool blanket shall be provided between the refractory backup and steel casing or between an inner and outer casing. Thickness of insulation shall be such that an average casing temperature in the furnace area will not exceed [55 degrees C (130 degrees F)] [_____] degrees C ([_____] degrees F) [130] [_____] degrees F with a surface air velocity of 508 mm per second (100 fpm), 100 fpm, and an ambient air temperature of 25 degrees C (80 degrees F) 80 degrees F when operating at full capacity.

2.2.2.3 HTW Generator Roof

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NOTE: For personnel safety, the design temperature of the casing surface should not exceed 65 degrees C (150 degrees F). Should the designer wish to use a design surface temperature between 55 and 65 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.

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Refractory lining conforming to manufacturer's requirements shall consist of not less than 65 mm 2-1/2 inches of high-duty refractory backup behind the roof tubes and sufficient thickness of high temperature block insulation or mineral-wool blanket suitable for the temperature encountered to limit casing temperature in the furnace area to 55 degrees C (130 degrees F) [_____] degrees C ([_____] degrees F), [130] [_____] degrees F, with a surface air velocity of 508 mm per second (100 fpm) 100 fpm and an ambient air temperature of 25 degrees C (80 degrees F) 80 degrees F when operating at full capacity. Manholes and other inspection and access openings, and identification plates and stamps shall have insulation finished neatly against a metal ring provided for this purpose.

2.2.2.4   Bridge Walls

Bridge walls exposed on all sides to radiant heat and the products of combustion shall be constructed of super-duty refractory not less than 457 mm (18 inches) 18 inches thick, conforming to manufacturer's requirements. Walls having only the front side exposed to radiant heat and the products of combustion shall have front facing and cap constructed of 225 mm (9 inches) 9 inches of super-duty refractory and back facing of not less than 225 mm (9 inches) 9 inches of low-duty firebrick. The base of the wall shall be common brick.

2.2.2.5   Settling Chamber

Settling chamber for the removal of fly ash shall be provided below the last pass of each HTW generator. Chamber shall have means for frequent cleaning without shutting down the HTW generators.

2.2.2.6   Expansion Joints

Expansion joints shall be provided where indicated and elsewhere 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) 4 inches sealed with resilient mineral wool suitable for 925 degrees C (1700 degrees F) to 1095 degrees C (2000 degrees F). 1700 to 2000 degrees F. In addition, to allow for expansion of the inner face, a series of 3 mm (1/8 inch) 1/8 inch wide vertical openings, spaced 1.8 m (6 feet) 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 as specified.

2.2.2.7   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 shall not be permitted. Maximum mortar joint thickness shall not exceed 3 mm (1/8 inch) 1/8 inch and average joint thickness shall not exceed 1.6 mm (1/16 inch). 1/16 inch.

2.2.2.8   Plastic Refractory

Plastic refractory shall be installed in accordance with the manufacturer's recommendation and by workmen skilled in its application.

2.2.3   Boiler Fittings and Appurtenances

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

2.2.3.1   Thermometer

Thermometer for HTW generator inlet water and outlet water shall be provided for each HTW generator in a visible location on the HTW generator.

2.2.3.2 Pressure Gauge

Pressure gauge shall be provided for each HTW generator in a visible location on the HTW generator.

2.2.3.3 Relief Safety Valves

HTW generator relief safety valves shall be installed such that the discharge shall be through piping extended to the plant blowoff tank. Relief valves shall be sized, constructed, and their set pressures shall be determined in accordance with ASME BPVC SEC I.

2.2.3.4 Drain Valves

Drain valves in tandem shall be provided at each drain point of blowdown as recommended by the HTW generator manufacturer. Piping shall conform to the requirements of ASME BPVC SEC I and shall be extra strong weight black steel pipe conforming to ASTM A 53/A 53M. Drain valves shall conform to ASME BPVC SEC I and shall be the balanced seatless type unless otherwise approved.

2.2.4 Soot Blowers

When required, HTW generator shall be provided with soot blowers using compressed air as the blowing medium. The soot blower system shall be the automatic sequencing and intermittent puff type, and the soot blower control unit shall be suitable for mounting on the generator control panels. The soot blower units shall be rotated automatically in successive steps by their controller, each step involving no more than a 69 kPa (10 psi) 10 psi drop in air pressure at the receiver. After one unit is operated in successive steps through its cycle, the controller shall shift the operation to the second soot blower unit, and so on, until all units on that generator have been operated, after which the controller shall be shut down automatically by the sequence controls. The soot blower heads shall have elements of suitable chrome alloy material for the temperatures encountered in the HTW generator. The sequence timer shall have provision for manual selection of the soot blower units to be used.

2.3 FUEL BURNING EQUIPMENT

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NOTE: The designer must include all the required data for proper design of the boiler. Delete all references to coal and stokers where oil is the only fuel to be utilized.

Paragraphs describing stoker equipment not required shall be deleted. Stokers and stoking equipment selected will be based on the following:

Boilers having output capacities of 3,517 kW (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 when bituminous coal with ash content on a dry basis in excess of eight percent or ash fusion temperature lower than 1200 degrees C (2,200 degrees F) is to be used. Pulsating grate

units will be water-cooled and complete with automatic coal feed and continuous ash removal. Conveyor stokers may be specified if suitable for the type of coal available. Chain or traveling grate may be specified by deletion of one type of grate, or the choice between the two types may be left to the Contractor by including both types in the description. The following is a general guide in determining which type of grates to investigate:

MW Output	(Size) Type of Grate and Stoker
735 - 5860	Single retort, stationary grate, underfeed stokers
5860 - 8800	Single retort, moving grate, underfeed stoker
1465 - 22000	Reciprocating grate, front continuous ash discharge stoker
1465 - 29500	Vibrating conveyor grate, front continuous ash discharge stoker
5860 - 36500	Water-cooled, incline grate, hopper fed vibrating grate stoker
8800 - 120,000	Spreader stoker, continuous front ash discharge

(MBtuh Output	(Size) Type of Grate and Stoker
2,500 - 20,000	Single retort, stationary grate, underfeed stokers
20,000 - 30,000	Single retort, moving grate, underfeed stoker
5,000 - 75,000	Reciprocating grate, front continuous ash discharge stoker
5,000 - 100,000	Vibrating conveyor grate, front continuous ash discharge stoker
20,000 - 125,000	Water-cooled, incline grate, hopper fed vibrating grate stoker
30,000 - 400,000	Spreader stoker, continuous front ash discharge)

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The HTW generator manufacturer shall certify that the stoker selected will be satisfactory for the HTW generator design. Stokers and HTW generator shall be capable of efficiently burning coal with fuel sizing conforming to

ABMA 202 for Stoker Firing of Bituminous Coals, approximately [_____] mm ([_____] inches) [_____] 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)	[_____]
Sulfur	[_____]
Chlorine	[_____]
Ash	[_____]
Oxygen (Diff)	[_____]
Btu/lb. as received	[_____]
Btu/lb. - dry	[_____]
Grindability	[_____]
Raw Fuel Size	[_____]

Ash Analysis	Percent
SiO_2	[_____]
Al_2O_3	[_____]
TiO_2	[_____]
Fe_2O_3	[_____]
CaO	[_____]
MgO	[_____]
Na_2O	[_____]
K_2O	[_____]
SO_3	[_____]

Ash Fusion Temperatures	Degrees C
Initial deformation temperature	[_____]
Softening temperature	[_____]
Fluid temperature	[_____]

Ash Fusion Temperatures	Degrees F
Initial deformation temperature	[_____]
Softening temperature	[_____]
Fluid temperature	[_____]

2.3.1 Spreader Stokers

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.

2.3.1.1 Grates

Grates for spreader stoker firing shall be high air resistant type 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 [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.

2.3.1.2 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 16 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.

2.3.1.3 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 16 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. The 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.

2.3.1.4 Controls

Stoker controls that accurately regulate the coal feed rate shall be 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 be only 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 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. Electric motor shall be [totally enclosed, fan-cooled] [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.

2.3.1.5 Hoppers

Hoppers shall be constructed of steel plates not less than 6.4 mm (1/4 inch) 1/4 inch thick and shall have a capacity of not less than [_____] kg ([_____] pounds) [_____] pounds per feeder. Hoppers shall be provided with cleanout 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] 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. The area under the grates shall be divided into not less than four air-tight 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 accordance with ASME BPVC SEC I.

2.3.1.6 Air Systems

Spreader stokers shall be provided with over-fire turbulence and cinder and dust reinjection systems. Either air or steam can 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 splash-proof 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.

2.3.2 Underfeed Stokers

2.3.2.1 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 electric motor drive and all necessary auxiliary equipment. Dumping power cylinders shall be compressed air actuated. Stokers shall be capable of handling the coal specified. 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.

2.3.2.2 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.

2.3.2.3 Ram Feed

Ram feed shall be mechanical, pneumatic, or hydraulic driven by an electric motor connected through an efficient gear reduction unit, crank shaft, and connecting rod. Motors shall be [totally enclosed fan-cooled type] [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.

2.3.2.4 Hoppers

Hoppers shall be constructed of steel plates not less than 6.4 mm (1/4 inch) 1/4 inch thick and shall have a capacity of not less than [_____] kg ([_____] pounds). [_____] pounds. Hoppers shall be provided with cleanout 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] 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. Water spray pipes and nozzles shall be provided for quenching the ashes in the ash pit.

2.3.3 Conveyor Stokers

Conveyor stokers shall be the grate level feed, forced draft [chain grate] [traveling grate] type and shall be provided complete with hoppers, feed gate, drive shaft, sprocket wheels, grate, drive, and all necessary auxiliary equipment. Stokers shall be capable of handling the coal specified. 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.

2.3.3.1 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.

2.3.3.2 Conveyor Grate

Conveyor grate shall be driven by [electric motor connected through a suitable speed-reduction unit] [hydraulically-operated variable speed drive]. All gears and chains required for the drive shall be enclosed in a dust-tight 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] [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] [dust-tight] [explosion-proof] enclosure.]

2.3.3.3 Hoppers

Hoppers shall be constructed of steel plates not less than 6.4 mm (1/4 inch) 1/4 inch thick, shall have a capacity of not less than [_____] kg ([_____] pounds), [_____] pounds, and shall be provided with suitable cleanout doors. Coal feed to the hoppers shall be fitted with concave type transitions to insure 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 insure 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 6.4 mm (1/4 inch) l/4 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 shall have provisions for ash removal.

2.3.4 Vibrating Grate Stokers

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 to discharge the ashes into the ash pit. Stokers shall be provided complete with hopper, feed gate, grate, drive mechanism, and all necessary auxiliary equipment. Stoker shall be capable of handling the specified coal. 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 air-tight zones for forced draft supply and shall have suitable zone control dampers with external indicating, operating, and locking devices.

2.3.4.1 Grates

Grates shall be either air-cooled or water-cooled with grate bars in intimate contact with the water tubes. Grates shall have individually replaceable sections of iron or steel suitable for the temperatures encountered. All pressure parts including water tubes, 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.

2.3.4.2 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 the 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. Bearing 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. 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 NFPA 70. Motor starter shall be magnetic, reversing [across-the-line] [reduced voltage start] type with [general-purpose] [dust-tight] [explosion-proof] enclosure.

2.3.4.3 Hoppers

Hoppers shall be constructed of steel plates not less than 6.4 mm (1/4 inch) 1/4 inch thick, shall have a capacity not less than [_____] kg ([_____] pounds), [_____] 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 insure 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 19.1 mm (5/8 inch) 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.

2.3.5 Burners

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NOTE: The designer must include all the required data for proper design of the boiler. Delete all references to coal and stokers where oil is the only fuel to be utilized.

****

Where indicated and specified, each HTW generator shall be provided with oil-fired burner or burners. The burner assembly and control systems shall conform to NFPA 8501, UL 296, and UL 726, except as otherwise specified. Supervised manual, semiautomatic, and fully automatic combustion safety controls shall conform to NFPA 8501 and ASME CSD-1.

2.3.6 Fuel Oil Pumping and Heating Sets

An integrated, shop-fabricated oil pumping and heating set shall be furnished and shall be duplex type, assuring 100 percent standby and the oil shall be heated by medium temperature water. Two positive displacement oil meters shall be provided. Each set shall include an electric oil heater of sufficient capacity to heat the specified fuel oil to ignition temperature at low generator load until enough HTW is generated to operate the high temperature water-to-low temperature water (LTW) heat exchanger and the LTW-to-oil heater. The electric heater shall be controlled by a magnetic starter with a manually-operated ON-OFF switch in series with a thermostatic control. When oil temperature is raised to proper level and maintained by the LTW heater, the electric heater shall be disconnected automatically by the thermostatic control. Fuel pumps shall be electric-motor driven. Each pump shall have the capacity of not less than [_____] liters per second ([_____] gpm) [_____] gpm at a discharge pressure of [_____] kPa ([_____] psig) [_____] psig with a suction lift of 3 m. 10 feet.

2.4 COMBUSTION CONTROL EQUIPMENT

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NOTE: Paragraphs describing inapplicable types of combustion control equipment will be deleted. The type of combustion control system specified for a project will depend largely on the boiler capacity, the fuel, initial cost, and cost of operation. Basically, the types should be as follows (the boiler capacities are expressed in Btuh and MW):

Type of Control	**Coal (MW)**	**Oil (MW)**
Positioning	**0.879-15**	**0.870 - 12**
Semimetering	**7-21**	**7-19**
Metering	**7 and above**	**7-19 and above**
Metering with oxygen compensation	**20 and above**	**20 and above**

(Type of Control	**Coal (Btuh)**	**Oil (Btuh)**
Positioning	**3-50 million**	**3-40 million**
Semimetering	**25-72 million**	**25-66 million**
Metering	**25 million and above**	**25 million and above**
Metering with oxygen compensation)	**68 million and above**	**68 million and above**

****

Combustion control equipment shall be provided as a system by a single manufacturer. Automatic combustion control system shall be installed for each boiler in accordance with the manufacturer's recommendations. Controllers shall be located on the designated heating plant master control center panel. The equipment shall operate either pneumatically, electrically, or electronically. Pneumatic control systems shall conform to ASME B19.3. 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 the dual type where one side can be cleaned and repaired while the other is operating. Exterior control air piping and devices shall be protected from freezing by use of regenerative desiccant dryers. 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 115 volts and shall be connected as specified in Section 16415A ELECTRICAL WORK, INTERIOR. Operating and limit controls shall be wired to interrupt the ungrounded circuit conductor. Controls and instruments shall conform to the requirements of ASME CSD-1, NFPA 8501, UL 296, and UL 726, except as otherwise specified. On multiple boiler installations, a means shall be provided to base load on individual boilers while on automatic control and each boiler unit shall be individually controlled.

2.4.1 Combustion Controls

Combustion controls shall be the [positioning] [semimetering] [metering] [metering with oxygen compensation] type. A plant master controller sensitive to temperature transmitter in return water header shall be furnished to provide anticipatory signals to all generator master controllers. Generator master or submaster controllers shall react to anticipatory signals from plant master and then adjust firing rate as necessary in response to generator outlet temperature indication to maintain preset temperature at each generator outlet. The precision of pressure or temperature control, expressed in percent, plus or minus, of the set point of the boiler pressure in kPa (psig), psig, or the temperature in degrees C (degrees F) degrees F during any load swings of up to 10 percent of the boiler capacity per minute over the entire turndown range, shall not exceed 3 percent.

2.4.2 Stoker Controls

The combustion control system shall be interlocked with the grate drive to balance the ash discharge with the firing rate. The coal feed flow rate may be used as the index of fuel feed. Stoker controls shall perform as outlined for the stoker specified.

2.4.3 Positioning Type Combustion Control Equipment

Positioning controls shall be a type wherein separate parallel controllers are provided for fuel feed and air flow, and both are modulated by the boiler load. Manual means shall be provided for readily adjusting the fuel-to-air ratio for the most efficient combustion. An adjustable compensating device shall maintain the proper ratio of fuel and air over the entire range of operation to provide combustion efficiency within the range specified. When a furnace draft controller is required, it shall be supplied. All controllers shall be flush-mounted on the control and instrument panel; all adjustments and calibrations of fuel feed, air flow and furnace draft, shall be made at the front of the panel.

2.4.4 Semimetering Type Combustion Control Equipment

Two controllers per boiler shall be provided, one for fuel feed and one for air flow. The first of these shall be positioned in proportion to the boiler load to deliver a proportionate impulse to the second controller which shall function in direct relation to that impulse; the second controller then shall measure the fuel feed or air flow provided and automatically make necessary adjustments to maintain the fuel-to-air ratio for which it is set over the entire range of operation. Furnace draft or pressure controllers shall be provided where required. All controllers shall be flush-mounted on the control and instrument panel; all adjustments and calibrations of fuel feed, air flow, and furnace draft or pressure, shall be made at the front of the panel, and indicators shall be provided to show the amount of adjustment and the results obtained.

2.4.5 Metering Type Combustion Control Equipment

Metering controls shall provide adequate means for automatically adjusting both fuel feed and air flow in strict relation to the load requirements. In addition, they shall measure the rates of fuel feed and air flow and maintain the required ratios over the full range of boiler operation. In addition to the master controller, there shall be separate controllers for fuel feed and air flow. These controllers shall respond either in parallel or series. Air flow-fuel flow cross limiting shall be included. [If required by a particular system, a separate fuel-to-air ratio controller may be provided.] Actual rate of fuel flow shall be metered accurately in the fuel line to the burner. Actual air flow may be measured by a differential orifice in the forced draft duct. Operation of either controller for both functions will not be acceptable. In addition, a separate controller shall be provided to control the draft or pressure in the boiler furnace. Controllers shall be flush-mounted on the control and instrument panel; all adjustments and calibrations of fuel feed, air flow, fuel-to-air ratio, and furnace draft or pressure, shall be made at the front of the panel and indicators shall be provided to show the degree of adjustment.

2.4.6 Combustion Control with Oxygen Trim

Flue gas oxygen trim may be provided as an adjunct to the metering system of control. The oxygen content in combustion gases shall be determined; from this, an impulse shall be sent to the oxygen controller, which shall readjust the air flow to maintain the required oxygen content. The oxygen set point shall be a function of generator load with operator biasing capability. The amount of oxygen controller trim shall be limited to prevent potentially hazardous conditions created by equipment failure or misoperation.

2.4.7 HTW Generator Limit Controls

Controls shall be provided to include low generator water flow and high generator temperature. The limit controls shall be interlocked with the combustion control system to provide for generator alarm and shutdown.

2.4.8 Burner Control/Fuel Safety System

2.4.8.1 Design Requirements

a. General: 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 all logic inputs and outputs and for monitoring availability of control power to all 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.

b. 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 as a minimum requirement of this specification. 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.

c. Adverse Electrical Conditions: All equipment shall be capable of operating as specified and without damage within the electrical environment of the plant. This environment includes, but is not necessarily limited to, high-voltage, high-frequency surges caused by electro-mechanical 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.

2.4.8.2 System Design

The burner control system shall be compatible in all respects with the HTW Generator and auxiliary equipment. The system design shall meet the requirements specified in NFPA 8501. The burner control system shall incorporate a continuous purge of the furnace to insure that the HTW Generator is free of any accumulation of combustibles. The burner control system shall also supervise the operation of the fuel-air equipment associated with fuel oil burners. It 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 of 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 command 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, ignition oil trip system, and main fuel oil trip system. 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 system, those that are required to provide overall HTW Generator 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.

2.4.8.3 System Functional Requirements

a. Operating Modes: The operator shall have the responsibility for initiating the start and stop sequences listed below. Once initiated the burner control system shall automatically place the oil burner in service or remove it from service.

The steps each of which require operator initiation are:

(1) Purge.

(2) Igniter control.

(3) Feeder control.

(4) Main oil burner.

b. Furnace Purge and Boiler Monitor: The furnace purge control shall incorporate prelight off and post purges of the furnace to insure that the HTW Generator 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 HTW Generator 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 relay is reset.

c. Igniter Control: An igniter group consists of all the igniters associated with a main oil burner. Igniters associated with a burner group shall be controlled from a separate electropneumatic igniter control package. Sequential starting of igniters between burner groups shall be provided. Igniters associated with a burner group shall be started and stopped from the insert panel and local pushbuttons. An igniter 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.

d. Main Oil Burner Control: Starting and stopping of each main oil burner may be accomplished either locally or from the insert panel. Proven igniter groups shall be one of the permissives required for starting. Fuel oil trip first out indications and a main fuel oil trip (FOT) relay shall be provided.

e. Fuel Safety Subsystem: The fuel safety subsystem comprises the MFT system, main FOT system, and IFT system. 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 operator insert panel. The MFT system shall provide overall HTW Generator protection, shall also include a dedicated hardwired relay, and shall directly trip all other fuel safety system relays. The system shall be designed to de-energize to trip.

f. Flame Monitoring: Individual self-checking flame scanners are required for each burner. Igniter 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 igniter flame and any other flame that may exist in the furnace. Igniter 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.

g. Enclosures: The system logic cabinets shall contain all 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 610 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.

h. Local Termination Boxes: The system shall include local junction boxes, one at each burner level. Burner level junction boxes shall contain separate pushbuttons and indicating lights for local control of each igniter 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.

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

j. 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.

2.5 HEATING PLANT PANELS AND INSTRUMENTS

Mercury shall not be used in thermometers.

2.5.1 HTW Generator Instrument and Control Panel

The HTW generator 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) 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. 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 engraved metal or laminated plastic nameplates securely fastened to the panel. The panel shall have continuous, rapid-start, fluorescent light fixtures mounted with reflectors providing suitable shielding to illuminate all controls, instruments, gauges, and meters. All field piping connections shall terminate in one bulkhead-mounted manifold located to conform with the installation requirements of the system. All field electrical wiring shall terminate in a suitably mounted color-coded terminal strip so located as to conform with the installation requirements of the system. 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. The control equipment shall include the necessary operating switches, indicating lights, gauges, alarms, the combustion control system, and the generator and fuel safety interlock systems. If the package type boiler burner units with integral controls are furnished, the control equipment for each boiler may be mounted on a separate free-standing panel in accordance with the requirements above for instrument and control panel. Controllers and indicators specified or required shall be panel-mounted and tested at the factory complete with relays, transformers, switches, wiring, valves, and piping. All wiring and piping within the panel shall be color-coded or otherwise identified.

2.5.2 Indicators

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

2.5.3 Recorders

Recorders shall be servo mechanism type, multiple pen type. [Circular] [Strip chart] type shall be provided. Minimum chart width is 100 mm (4 inches). 4 inches. Accuracy shall be plus or minus 1/2 percent. Each pen shall have a separate scale calibrated in engineering units. Chart drive shall be 120 volts ac. One year's supply of chart paper shall be provided.

2.5.4 Panel Display

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

	Indicator	Recorder Point
Pressure		
Main hot water header	x	x
Boiler drum	x	
Feedwater	x	x
Instrument air	x	

	Indicator	Recorder Point
Draft		
Windbox	x	x
Furnace	x	
Gas outlet	x	
ID fan inlet	x	

	Indicator	Recorder Point
Temperature		
Hot water outlet		x
Boiler gas outlet		x
Windbox		x

	Indicator	Recorder	Point
Temperature			
Feedwater		x	
HTW differential temperature		x	
HTW zone inlet and outlet (each zone)		x	

	Indicator	Recorder	Point
Level			
Bunker or silo		x	

	Indicator	Recorder	Point
Flow			
Hot water outlet (including totalizer)		x	
Feedwater		x	
Air		x	
Fuel		x	
HTW (each zone)		x	

	Indicator	Recorder	Point
Analyzers			
Flue gas opacity		x	
Flue gas oxygen		x	

2.5.5 Hot Water and Feedwater Flow Measurement

Orifice plates shall be provided to measure hot water and feedwater flow to each generator. 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 XR0104.

2.5.6 Pressure Gauges

Heavy-duty industrial type pressure gauges with phenolic case, solid front, rear blowout, threaded ring, shatterproof glass, and 15 mm (1/2 inch) 1/2 inch NPT bottom connection shall be installed for proper operation. Pressure gauges shall be stainless steel Bourdon spring-type with 114 mm (4-1/2 inch) 4-1/2 inch dial sizes. Each gauge shall be installed where it is clearly visible from the operating level, and all requisite piping and gauge cocks described, or required above, shall be provided. Pressure gauges on high temperature service shall be provided with pigtail siphons. All gauges located on pump discharge lines shall be provided with pulsation dampeners or snubbers. Gauge ranges shall be selected so that at normal operation the pointer shall be approximately 50 percent of range. Gauges shall be supplied for the following services:

Expansion Tank
Dump Tank
Master Control Center
Circulation Pump Panel
Distribution System Mains

Master Control Panel
Makeup Pumps
Emergency Feed Pump
Water Main
Chemical Feed Pumps
Air Compressors
Fuel Oil Supply Header
Generator Pressure
HTW Water Inlet and
Outlet Duplex

2.5.7 Dial Indicating Thermometers

Thermometers shall be bimetallic type with stainless steel case and stem, and shall be provided with thermowells. Thermometers shall have a 127.0 mm (5 inch) 5 inch dial and plus or minus 1 percent accuracy.

2.5.7.1 Expansion Tank and Dump Tank Thermometers

Three thermometers shall be installed on each tank. The thermometers shall be installed at the drum centerline, at the top 1/3 point, and at the lower 1/3 point of the drum.

2.5.7.2 Inlet and Outlet Gauges of HTW Generators

Inlet and outlet gauges of HTW generators shall be as above, as applicable.

2.5.8 Remote Reading Temperature Indicators

2.5.8.1 Pump Thermometers

HTW generator and distribution system circulation pump panel thermometers shall be dial type, liquid filled, surface panel mounting, back-connected, 150 mm (6 inch) 6 inch turret type phenolic case, range 35 to 260 degrees C (100 to 500 degrees F), 100 to 500 degrees F, with self-compensating stainless steel 3 m 10 foot long capillary having a stainless steel separable socket with a 65 mm (2-1/2 inch) 2-1/2 inch extension neck, 150 mm (6 inch) 6 inch bulb length, 20 mm (3/4 inch) 3/4 inch IPS connection.

2.5.8.2 Pipeline Thermometers

Pipeline thermometers, as indicated, shall be similar to above with 65 mm (2-1/2 inch) 2-l/2 inch extension neck separable sockets, where accessible, and with required capillary length where not accessible, for direct reading.

2.5.8.3 Flue Gas and Fuel Oil (if Oil-Fired) Thermometers

Temperature indicators shall be the vertical scale, moving pointer type, in semiflush mounting dust-tight case, with curved translucent scales, internally illuminated. The instrument scale graduations, figures, and range shall suit the indicated service. The instrument shall employ a diaphragm measuring element with linkage actuation of the indication pointer. Thermal sensing element shall be the gas-filled bulb type with spirally wound, bronze armored flexible copper connection tubing to the instrument. Instrument accuracy shall be 2 percent of full scale range with a sensitivity of 0.2 percent of full scale range.

2.5.8.4 Separable Sockets

At all points of recording, controlling, or integrating instrument temperature bulb insertion, a stainless steel separable socket having a screwed cover and attachment chain shall be installed adjacent to a temperature bulb for insertion of a test thermometer.

2.5.9 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, all 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.

2.5.10 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 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.

2.5.11 Fuel Flow Meter

The meter shall be of the volumetric measurement type incorporating a rotary, positive displacement piston body with gear train driven generator and totalizing register, a panel-mounting meter to indicate fuel oil rate of flow in gallons per minute, and a transmitter output signal of 4 to 20 mA dc to be used for combustion control. The meter body shall be bronze with hard-cast bronze measuring piston. The generator shall be totally enclosed with grease-packed ball bearings, silver commutator, and brushes. The totalizing register shall be mounted on top of the generator housing and shall be calibrated in liters (U.S. gallons). U.S. gallons.

2.5.12 Water Flow Meter

Water flow recorder with totalizer shall be provided for each generator. Recorder shall otherwise conform to the requirements specified for the HTW temperature recorder except that flow rates will be recorded in liters per second (gpm). gpm.

2.5.13   Btu Recorder

Each HTW generator shall be provided with a recording totalizer which shall integrate temperature difference and water flow to provide the net joule (Btu) Btu output of the generator.

2.5.14   Makeup Water Meter

A makeup water meter shall be provided in the treated water line. The meter shall be of the positive displacement type and shall be suitable for operation with water at 21 degrees C (70 degrees F), 70 degrees F, and 450 kPa (65 psig). 65 psig. The complete meter assembly shall include meter isolation valves and a valved bypass and strainer on the inlet side of the meter. The dial shall be 254.0 mm (10 inch) 10 inch diameter vertical type calibrated in liters (gallons) gallons and having two hands; 380 liters (100 gallons) 100 gallons indicated on one hand and 7570 liters (2000 gallons) 2000 gallons on the other hand. The hands shall have a manual reset device. A totalizing register shall be provided. All bearings shall be self-lubricating if submerged. The meter capacity shall be [_____] liters per second ([_____] gpm). [_____] gpm.

2.5.15   Master Control Center

A centrally located master control center shall be provided to serve as the central control and recording station for the plant. The master control panel shall serve as a central point for miscellaneous functions including the various alarm circuits with their annunciators and audible signals, and the controls for the system. The units to be installed on the panel are specified under the various paragraphs of this specification. All necessary electric wiring for instruments, panel lighting, and equipment requiring electrical connections shall be installed. All necessary transformers, separate relays, switches, and fuses shall be installed in a fully enclosed junction box. A safety switch with fuses shall serve the 120-volt power supply to the plug-in strip and any other power supply as required for control circuits. All wire shall be suitable for boiler room requirements and installed according to NFPA 70. All necessary interconnecting piping, terminal block, valves, and fittings required for the control equipment shall be installed and supported in place on the rear of the panel and tested at the factory.

2.5.15.1   Panel Board

A free-standing master panel board shall be floor-mounted on a 100 mm 4 inch concrete curb and provided with vibration isolators between panel and anchor bolts. The control panel shall be constructed of specially leveled steel sheet not less than 4.8 mm (3/16 inch) 3/16 inch thick with adequate structural steel framework to provide a rigid unit. The panel shall be provided with gaskets and other seals necessary to form a dust-tight enclosure of the controls conforming to NEMA ICS 1standards. Nameplates shall identify all controls and instruments. The panelboard shall match the boiler control units and distribution panel in appearance, unless it is a console type. A suitable plug-in strip shall be provided on the rear of the panel for any required plug-in electrical connections of the instruments. All necessary piping or electrical connections and all necessary devices for a complete operating installation shall be provided. Suitable single strip, rapid start fluorescent lighting with a panel-mounted toggle switch shall be supplied for a panelhood. A single, pull chain, ceiling light receptacle shall be installed in the interior of the panel enclosure and wired to the common point of electrical supply.

2.5.15.2 Distribution Zone Valve Controls

A manual valve control for each zone control valve shall be provided on the master panel. Instruments shall be provided to indicate the position of each valve operator.

2.5.15.3 Expansion Tank Water Level Indicator

A water level indicator shall be provided on the master control panel and shall be of the remote reading, liquid level indicator type. The indicating scale shall show uniform divisions for all level changes and shall require no liquids for calibration other than the expansion drum water. The instrument shall be suitable for 2,758 kPa (400 psig) 400 psig operating pressure. The instrument shall be so connected and calibrated that it will indicate levels of [_____] mm ([_____] inches) [_____] inches to [_____] mm ([_____] inches) [_____] inches above the outside bottom of the expansion tank. The primary or transmitting elements shall be located at the liquid level control station as shown. The instrument shall be so located and calibrated that the center point of the indicator will show the normal water level in the tank at [_____] mm ([_____] inches) [_____] inches above the tank bottom.

2.5.15.4 Annunciator

An annunciator system shall be provided with a semiflush mounted panel. Annunciator system shall indicate and alarm on the following:

a. Expansion Tank:

Overflow level
Normal level
Combustion cutout level
High pressure
Low pressure

b. Dump tank:

Overflow level
High pressure
Low pressure

c. HTW generator (each) - safety shutdown

d. Fuel (to suit firing system):

Low fuel oil header pressure
Low fuel oil storage level
Low stoker hopper level
Low coal bunker level

e. Air:

Low service air pressure
Low instrument air pressure if pneumatic controls are used

f. Distribution zones (each) - low return pressure

The annunciator shall be provided with lamp test and acknowledge push buttons. The operational sequence shall be as follows:

Condition normal	-	Light off, horn off
Alarm	-	Light flashing, horn on
Alarm acknowledged	-	Light on, horn off
Return to normal	-	Light off, horn off

The system shall be provided with devices to actuate the annunciator from the above sources, unless otherwise specified.

2.5.15.5 Liquid Level Control Stations

Liquid level control stations shall be provided at the expansion tank and dump tank, and shall include adequate detection, sensing, and actuating devices to provide signals for the annunciator system and to control the overflow system. The levels for carrying out the above functions shall be as indicated.

a. Expansion Tank Overflow Controller: Overflow control system from the expansion tank shall be provided. The expansion tank shall overflow on control signal from the control station specified above which shall actuate a motorized normally-closed valve allowing water to relieve to the dump tank.

b. Dump Tank Overflow Controller: Overflow control system from the dump tank shall be provided. The dump tank shall overflow on control signal from the controller which shall actuate a motorized normally-closed valve allowing water to relieve to the blowdown tank.

2.5.15.6 Distribution Zones Control Station

A control station for distribution zones valve control shall be provided with one manual valve control for each zone. The instrument shall indicate the position of the valve operator and shall provide remote control and adjustment of the valve. The controlled valve shall be a motorized gate valve in the distribution zone supply line for emergency shutoff and flow modulation. The motorization of the valve shall be such that any partial opening of the valve may be held positively without drift or consumption of a power means. The valve body shall conform to the requirements for valves specified in paragraph PIPING.

2.5.15.7 Plant Master Controller

Plant master controller for nitrogen pressurized systems shall react in response to temperature transmitter signals from a temperature sensing element in the return water header and shall provide the necessary signals to the HTW generator master controllers. The plant master controller shall have a manual selector station for selecting either automatic control or manual control and a means for adjusting the set point return water temperature control.

2.5.15.8 Clock

The clock shall be electric synchronous motor type conforming to CID A-A-1509, except as modified herein. 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 380 mm (15 inch) 15 inch size.

2.5.16 Panel Piping and Wiring

High-pressure and high-temperature values shall be pneumatically or electrically transmitted, or both, to the panel. Pneumatic signals shall be 3 to 15 psig. Piping connectors to indicators shall be 6.4 mm (1/4 inch) 1/4 inch OD copper tubing conforming to ASTM B 68MASTM B 68. 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.

2.5.17 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) 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.

2.5.18 Continuous Emissions Monitoring

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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 1(0 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 fine 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.

2.6 NITROGEN PRESSURIZATION SYSTEM

A complete system of nitrogen pressurization shall be provided including necessary equipment, parts, pressure vessels, piping, valves, devices, and accessories. The system shall allow proper HTW expansion and contraction, and control of makeup water with a minimum loss of nitrogen and HTW while maintaining the system pressures corresponding to the operating range of the combustion control of 5.5 degrees C (10 degrees F) 10 degrees F above or below the boiler-outlet water temperature, without steaming in the system.

2.6.1 Expansion Tank

One expansion tank shall be furnished. The tank shall be constructed, stamped, and certified in accordance with ASME BPVC SEC VIII D1 for an operating pressure of [_____] kPa ([_____] psig) [_____] psig and temperature of [_____] degrees C ([_____] degrees F). [_____] degrees F. Connections and piping inserts shall be adequately supported structurally as required for the service. A standard manhole, actuating device for feed water control, alarm devices, gauge glasses, floats, and controls as required, shall be provided for the proper functioning of the expansion tank. Expansion tank shall be hydrostatically tested at the factory.

2.6.2 Dump Tank

A dump tank shall be furnished. The tank shall be constructed, stamped, and certified in accordance with ASME BPVC SEC VIII D1 for an operating pressure of [_____] kPa ([_____] psig) [_____] psig and [_____] degrees C

([_____] degrees F). [_____] degrees F. Connections and piping inserts shall be adequately supported structurally as required for the service. A standard manhole, actuating services for makeup water control, alarm devices, gauge glasses with shields, floats, and controls as required, shall be provided as indicated for the proper functioning of the dump tank. The tank shall be factory tested hydrostatically as specified.

2.6.3 Expansion Tank and Dump Tank Fittings

Tank fittings shall conform to ASME BPVC SEC VIII D1 and shall include the following:

a. Pressure gauge.

b. Water level gauge.

c. Level controls.

d. Thermometer.

e. Drain valves; hard seat, seatless pattern; rating 400 to 600 pound class.

f. Vent valves; Class 600, 600 pound, steel bar stock, OS&Y.

g. Safety relief valves shall conform to ASME B16.34, and shall be suitable for a HTW expansion drum at working pressure of [_____] kPa ([_____] psig), [_____] psig, except all internal parts shall be of steel or stainless steel with hard facing allowable.

2.7 BLOWOFF SYSTEM

2.7.1 Sample Cooler

Sample cooler shall be water-cooled shell-and-tube type heat exchanger with stainless steel tubes 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 steel sampling cock. 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 boiler blowoff and reading in parts per million shall be provided.

2.7.2 Blowoff Tank

A concrete blowoff tank shall be provided as indicated. The tank shall be provided with bolted manhole cover, cover plate with disappearing lifts, inlet blowoff connection equipped with mixing nozzle, vent, overflow and drain connection.

2.8 WASTE HEAT RECOVERY EQUIPMENT

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NOTE: For the efficiencies specified, waste heat recovery will be required. Designer must consult with HTW generator manufacturers to select the most appropriate unit for the size of HTW generator being designed.

****

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 provisions for tube or tube bundle removal and for cleaning. Soot blowers shall be provided as specified.

2.8.1 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 provisions for cleaning and tube bundle removal. Materials shall be capable of withstanding the maximum boiler exit gas temperature plus 28 degrees C (50 degrees F). 50 degrees F. The tubes shall conform to ASME BPVC SEC I. The overall design and installation shall be such as to 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.

2.8.2 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 all 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 air-preheat or by automatic bypass and shall be integrated with the combustion control system.

2.9 DRAFT FANS

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NOTE: 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] 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 minimum margins of 10 percent volume and 21 percent static pressure, plus margins of 5 degrees C (10 degrees F) 10 degrees F for forced-draft fans and 22 degrees C (40 degrees F) 40 degrees F for induced-draft fans. Induced-draft fans shall be designed for handling hot flue gas at the maximum outlet temperature adjusted for surface fouling. [Induced-draft fans shall be provided with outlet dampers.] Noise levels for fans shall not exceed 85 decibels at 914 mm (3 foot) 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.]

2.9.1   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.

2.9.2   Draft Fan Drives

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

Fan shall be driven by an electric motor. 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] [water-tight] [dust-tight] [explosion-proof] enclosure and shall be furnished with four auxiliary interlock contacts.]

2.10   AIR DUCTS

Air ducts connecting the forced-draft fan units with the stoker plenum 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 A 653/A 653M. 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 completely free from 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 x 38 x 3.2 mm (1-1/2 x 1-1/2 x 1/8 inch) 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:

Duct, Maximum Dimension	Galvanized Steel Sheet, Minimum Thickness
Up through 1525 mm	1.613 mm
Up through 60 inches	16 gauge
1526 m and larger	2.753 mm
61 inches and larger	12 gauge

Duct, Maximum Dimension   Galvanized Steel Sheet, Minimum Thickness

2.11 BREECHING

Breeching shall be constructed of not less than 3.416 mm (10 gauge) 10 gauge steel sheets conforming to ASTM A 366/A 366M or ASTM A 36/A 36M. 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 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.

2.12 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, cleanout 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 485 degrees C (900 degrees F) 900 degrees F with intermittent temperatures up to 650 degrees C (1200 degrees F) 1200 degrees F and the wall section shall provide a "U" factor of approximately 0.26. Stacks shall be fabricated of high-strength, low alloy, structural steel resistant to atmospheric corrosion and conforming to ASTM A 242/A 242M 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.

2.13 ELECTRIC MOTOR-DRIVEN PUMPS

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

****

Electric motor-driven pumps shall be provided. Motors shall be [splash-proof] [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.

2.13.1 HTW Circulating Pumps

HTW circulating pumps shall be sized and designed for the specific application. Pumps having a combined rating of flow and head that results in a horsepower rating less than 185 kW (250 bhp) 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, multi-stage centrifugal pumps and which conform to HI 1.1-1.5. 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.

2.13.1.1 Suction and Discharge Flanges

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 feed pump shall not be less than 205 degrees C (400 degrees F). 400 degree 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). 500 bhp. This applies to both frame cooling or seal cooling. Below 375 kW (500 bhp), 500 bhp, pumps shall employ antifriction radial and thrust bearings, lubricated by flinger rings in a sealed housing. Seals shall be mechanical with air-cooled flush piping conforming to API Std 610, Plan 23. Above 375 kW (500 bhp), 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 0.025 L per 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.

2.13.1.2 Structural Steel Bases

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.

2.13.1.3 Pump Coupling and Guard

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

2.13.1.4 Recirculation Control Valve

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.

2.13.1.5 Pump Testing

Pumps shall be subjected to shop hydrostatic testing. One pump in each service shall be subjected to complete shop performance tests 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.

2.13.1.6 Instrument Panel

Each HTW circulation pump shall be provided with an instrument panel. The construction and arrangement of the gauge panel shall be as indicated. Nameplates that conform to shall be provided designating the pump number and service. Letters shall be 6.4 mm (1/4 inch) 1/4 inch high. Gauges shall be surface panel mounted. The instruments shall be as specified above and shall include one single-element pressure gauge for the pump suction, one duplex pressure gauge with two elements to indicate flow pressure on each side of the pump discharge regulating valve, and one dial type thermometer to indicate the discharge temperature. Suitable identification letterings shall be supplied either on the gauge dial or on a nameplate adjacent to the gauge identifying the service of the gauge. A suitable stainless steel socket with cover for a separable socket-type test thermometer shall be installed in the pump discharge piping at each circulation pump for future insertion of a test thermometer. Pressure gauges shall have a gauge valve and a pigtail siphon as specified installed at the point of connection with the main piping. Pressure gauges connected to the pump discharge shall have pulsation dampeners or snubbers.

2.13.2 Emergency Makeup Water Pump

Emergency makeup water pump shall be the centrifugal type which conforms to HI 1.1-1.5. Pump shall be the split case, 2 stage type with closed impellers and radial or mixed flow. Pump shall be designed to handle high temperature water at 122 degrees C (250 degrees F), 250 degrees F, specific gravity of 0.942, pH of 9.5 to 10.5, and shall have the capacity and head indicated.

2.13.3 Makeup Water 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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Makeup water 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 sight glass provided. Pumps shall be subjected to the same tests specified for the HTW circulating pumps.

2.13.4 LTW Circulation Pump

The pump shall be the centrifugal type which conforms to HI 1.1-1.5. Pump shall be the end suction, single stage type with closed, open, or semi-open impellers and radial or mixed flow. Pump shall be designed to handle low temperature water at 110 degrees C (225 degrees F) 225 degrees F and shall have the capacity and head indicated.

2.14 LTW EXPANSION TANK

LTW expansion tank in connection with the LTW water heater shall be constructed in accordance with ASME BPVC SEC VIII D1 and shall have the dimensions indicated. The tank shall have the openings indicated and shall be provided with a protected gauge glass and manual air vent. The tank shall be tested hydrostatically at 1-1/2 times the working pressure or at 690 kPa (100 psig), 100 psig, whichever is greater.

2.15 HEAT EXCHANGERS

2.15.1 Water Heaters

Water heaters shall be of the types indicated and shall be provided with thermostatic control valves, valved bypasses, strainers, and temperature/pressure relief valves. Thermometers shall be provided where shown. Temperature and pressure relief valves shall conform to the requirements of ANSI Z21.22. Separate valves shall be provided if input exceeds 29.3 kW (100,000 Btuh) 100,000 Btuh or storage capacity exceeds 454 liters (120 gallons). 120 gallons. Thermostatic control valves shall be installed in the HTW return line from each water heater coil. The valve shall be installed to operate in conjunction with a remote bulb temperature controller and shall conform to the requirements of paragraph on thermostatic regulating valves. Valves shall be flanged, minimum Class 300 300 pound class, and sized for the service by the manufacturer. Instantaneous water heaters shall be shell-and-tube design conforming to the applicable requirements of TEMA Stds, Class C. The heater shell shall be steel and shall be designed for [_____] kPa ([_____] psi) [_____] psi and [_____] degrees C ([_____] degrees F) [_____] degrees F temperature. The coil shall be U-tube type designed for high temperature water at [_____] kPa ([_____] psi) [_____] psi pressure. The coil tubing shall be 18 mm (5/8 inch) 5/8 inch or 20 mm (3/4 inch) 3/4 inch size, constructed of No. 16 AWG cupronickel (90 percent/10 percent).

2.15.2 LTW Heat Exchanger for Fuel Oil Heating

The heater shall be instantaneous shell-and-tube type conforming to the applicable requirements of TEMA Stds, Class C. The heater shell shall be steel and shall be designed for [_____] kPa ([_____] psi) [_____] psi pressure and [_____] degrees C ([_____] degrees F) [_____] degrees F temperature. The coil shall be U-tube type designed for HTW at [_____] kPa ([_____] psi) [_____] psi pressure. The coil shall be constructed of No. 16 AWG 18 mm (5/8 inch) 5/8 inch or 20 mm (3/4 inch) 3/4 inch cupronickel (90 percent - 10 percent) tubing.

2.16 CHEMICAL TREATMENT AND WATER SOFTENING EQUIPMENT

2.16.1 Chemical Feeder

A feeder unit shall be provided for each boiler. Chemical feeder shall be automatic proportioning, shot type, 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.

2.16.2 Chemical Feed Pumps and Tanks

Chemical feed pumps and tanks shall be furnished as a package with the pumps mounted on and piping connected to the tank. 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 15 mm (1/2 inch) 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 HTW return line to the system circulating pumps and shall have capacity to feed a maximum of 5.3 mL per second (5 gph). 5 gph.

2.16.3 Water Softening Equipment

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NOTE: If softening equipment for makeup water is not required as determined in accordance with TM 5-810-1 , entire paragraph should be deleted. If water softening equipment is required, list desired water treatment conditions; e.g., pH level, hardness, chemical concentrations.

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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). [_____] 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) [_____] gallons of water of [_____] g ([_____] grains) [_____] grains hardness when operating at a sustained softening rate of [_____] liters per second ([_____] gpm). [_____] gpm. The system shall be based on the data below. Test sets shall be provided for pH comparator for the range [_____] to [_____] sulfide comparator, and phosphate comparator.

2.16.3.1 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

Constituents*	
Hydroxides as (OH)	[_____] ppm
Sulphates as (SO(4))	[_____] ppm
Chlorides as (Cl)	[_____] ppm
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.

2.16.3.2 Zeolite

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

2.16.3.3 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 0.679 L per square meter per second (1 gallon per square foot per minute) one gallon per square foot per minute for each 111 mm (4-3/8 inches) 4-3/8 inches of zeolite bed depth.

2.16.3.4 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.

2.16.3.5 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.

2.16.3.6 Treated Water Storage Tank

Treated water storage tank shall be fabricated from steel plates not less than 4.7625 mm (0.1875 inch) 0.1875 inch thick for shell and heads, and shall be constructed in accordance with ASME BPVC SEC VIII D1 for a design working pressure of 520 kPa (75 psig). 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 200 mm (8 inch) 8 inch copper ball float, lever-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). [_____] gallons. The tank shall be hydrostatically tested at the factory at not less than 690 kPa (100 psig). 100 psig.

2.17 HTW SPECIALTIES

2.17.1 Sediment Trap and Blender

The sediment trap shall be constructed, stamped, and certified in accordance with ASME BPVC SEC VIII D1 for an operating pressure of [_____] Pa ([_____] psig) [_____] psig and [_____] degrees C ([_____] degrees F). [_____] degrees F. The receiver shall be sized for maximum plant flow condition of [_____] liters per second ([_____] gpm) [_____] gpm and maximum flow velocity of 150 mm per second (0.5 fps). 0.5 fps. Receiver heads shall be flanged and dished and all tank nozzles 50 mm (2 inches) 2 inches and larger shall be flanged Class 300 300 pound class. An inspection handhole shall be provided. The receiver shall be hydrostatically tested.

2.17.2 Line Mixer

The line mixer shall be fabricated as indicated using seamless steel welding pipe fittings. Area of holes drilled in the HTW injector pipe shall equal or exceed 1.5 times the cross-sectional area of the injector pipe.

2.17.3 Liquid Level Control Column

The column shall be fabricated as indicated using seamless steel pipe and standard welding fittings. Forged steel pipe weldolets shall be used for gauge glass piping connections and float switch connections.

2.18 AIR COMPRESSORS

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

2.18.1 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 all 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 with ASME BPVC SEC VIII D1 and shall be equipped with flanged inlet and outlet connections, valved drain connection, 152 mm (6 inch) 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.

2.18.2 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 [_____] kPa ([_____] psig) [_____] psig not less than 0.00472 cubic meter per second (10 scfm) 10 scfm dry air at an atmospheric dew point of minus 23 degrees C (10 degrees F) 10 degrees F with entering air at 35 degrees C (95 degrees F), 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 with 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.

2.19 PIPING

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

2.19.1 Pipe

Pipe material shall be as specified in TABLE I, except fuel oil pipe material shall comply with Section 13202 FUEL STORAGE SYSTEMS.

2.19.2 Fittings

Pipe fittings shall be as specified in TABLE II, except fuel oil fittings shall comply with Section 13202 FUEL STORAGE SYSTEMS.

2.19.3 Nipples

Nipples shall conform to ASTM A 733, Type I or II, as required to match adjacent piping.

2.19.4 Unions

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

2.19.5 Pipe Threads

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

2.19.6 Pipe Expansion

2.19.6.1 Expansion Joints

Expansion joints shall be designed for a HTW working pressure not less than [_____] kPa ([_____] psig) [_____] psig and shall be in accordance with applicable requirements of ASME B31.1 and EJMA Stds. End connections shall be flanged. [Service outlets shall be provided where indicated or required.] Type II joints shall be suitable for repacking under full line pressure.

2.19.6.2 Flexible Ball Joints

Flexible ball joints shall be constructed of [stainless steel] [carbon steel] or other alloys as appropriate for the service intended. The joints shall be 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 ASME BPVC SEC VIII D1 where applicable. Flanges shall conform to the diameter and drilling of ASME B16.5. Molded gaskets shall be suitable for the service intended.

2.19.7 Valves

Valves shall be installed at all indicated locations, where specified, and where required for proper functioning and servicing of the system. Motor-operated valves shall be capable of closing speeds of 2.5 to 5.1 mm per second (6 to 12 inches per minute). 6 to 12 inches per 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 electric current characteristics indicated.

2.19.7.1 Check Valves

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

****

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

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

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

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

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

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

c. Valves for Class 300 300 pound class steel piping shall conform to the following:

(1) Sizes 65 mm (2-1/2 inches) 2-1/2 inches and less, bronze: MSS SP-80, Class 300 minimum.

(2) Sizes 80 mm (3 inches) 3 inches through 600 mm (24 inches), 24 inches, steel: ASME B16.34, Class 300 minimum flanged ends, swing disc.

2.19.7.2 Gate Valves

Unless otherwise indicated or specified, gate valves used as shutoff valves at main headers and elsewhere, as indicated, shall be the chain-operated type and shall have sufficient chain for easy operation from the operating floor or walkway. Gate valves 200 mm (8 inches) 8 inches and larger shall be provided with a globe valve bypass. Gate valves shall be the wedge disc type with outside screw and yoke and bonnet bushings. Valve body shall have straight-through ports without recesses except between seats to assure minimum turbulence, erosion, and resistance to flow. Motor-operated gate valves shall be installed in the HTW supply and return mains, where indicated, to isolate the distribution zones from the plant in case of a line break. The valves shall be closed by a pressure switch operated by return main water pressure. The pressure switch shall be the Bourdon tube, actuated mercury switch type with an adjustable operating range of 345 to 2413 kPa (50 to 350 psi). 50 to 350 psi. A three-position selector switch shall also be provided for automatic or manual operation of the valve position.

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

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

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

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

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

(2) Sizes 80 mm (3 inches) 3 inches through 610 mm (24 inches), 24 inches, steel: ASME B16.34, Class 150 minimum, flanged ends.

c. Valves for Class 300 300 pound class steel piping shall conform to the following:

(1) Sizes 65 mm (2-1/2 inches) 2-1/2 inches and less, bronze: MSS SP-80, Type 1 or 2, Class 300 minimum.

(2) Sizes 80 mm (3 inches) 3 inches through 610 mm (24 inches), 24 inches, steel: ASME B16.34, Class 300 minimum, flanged ends.

2.19.7.3 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 distribution system bypass motor-operated globe-valved piping connection between the supply and return mains, where required, shall be installed to ensure uninterrupted water flow to the HTW generator in case of low return pressure. In operation, valve shall modulate to the open position on low return main pressure signal. A three position selector switch shall be provided for automatic or manual selection of valve position. For each distribution zone, a manually-operated handwheel or chainwheel globe valve shall be installed in each high temperature return main to control the flow and the resultant differential temperature drop through each system.

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

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

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

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

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

(2) Sizes 80 mm (3 inches) 3 inches through 610 mm (24 inches), 24 inches, steel: ASME B16.34, Class 150 minimum, flanged ends.

c. Valves for Class 300 300 pound class steel piping shall conform to the following:

(1) Sizes 65 mm (2-1/2 inches) 2-1/2 inches and less, bronze: MSS SP-80, Type 1, 2, or 3, Class 300 minimum.

(2) Sizes 80 mm (3 inches) 3 inches through 610 mm (24 inches),

24 inches, steel: ASME B16.34, Class 300 minimum, flanged ends.

2.19.7.4 Thermostatic Regulating Valve

a. Cooling Water Control Valves: A thermostatically-operated flow control valve shall be installed in the cooling water piping from each HTW circulating pump, each air compressor, and each aftercooler to control the flow of the cooling water automatically, to prevent the waste of water, and provide proper operating temperature for the bearings. The valve shall match the piping size to which it is connected. Valves shall be suitable for operation on 1,034 kPa (150 psi) 150 psi water pressure, shall have threaded ends, and shall be direct-acting to open on temperature increase. The valve body shall have a 3.2 mm (1/8 inch) 1/8 inch hole drilled through the wall separating the inlet and outlet ports so that water circulation is not completely shut off. The valve shall have a nonmetallic disc and means for preventing the water from coming in contact with the range spring and sliding parts. A manual adjustment of the setting shall be provided. The range shall be 29 to 51 degrees C (85 to 125 degrees F) 85 to 125 degrees F and factory set for 38 degrees C (100 degrees F). 100 degrees F. The temperature bulb shall be for closed tank immersion with 15 mm (1/2 inch) 1/2 inch NPT connector.

b. Makeup Water Heater Control Valve: A temperature controller shall be installed in the high temperature return water line from the feedwater heater coil. The valve shall be motor-operated and shall operate in conjunction with the remote bulb temperature controller. Both valve and controller shall be the reverse-acting type failing in the closed position. The normal operating range shall be fully open at 79 degrees C (175 degrees F) 175 degrees F and fully closed at 100 degrees C (210 degrees F) 210 degrees F feedwater temperature. The controller shall modulate the flow between these points. The valve shall have a cast steel body, stainless steel trim, and lubricated deep-type stuffing box with packing suitable for the conditions. The valve disc shall be top-and-bottom guided of the equal percentage type. The valve shall be single-seated for tight closing, [_____] mm ([_____] inch) [_____] inch body size, flanged, passing [_____] kg per second ([_____] pounds per hour) [_____] pounds per hour of HTW at a maximum pressure drop of 15 m (50 foot) 50 foot head.

c. LTW Heater Control Valve: A thermostatic control valve shall be installed to operate in conjunction with a remote bulb temperature controller. The valve operating range shall be 93 to 110 degrees C (200 to 225 degrees F) 200 to 225 degrees F and valve shall modulate the flow of HTW to maintain LTW between these temperatures. The valve shall have a cast steel body with stainless steel trim, and lubricated deep-type stuffing box with packing suitable for the temperature and pressure conditions. The valve shall be single-seated, [_____] body size, to pass [_____] kg per second ([_____] pounds per hour) [_____] pounds per hour of HTW at a maximum pressure drop of 15 m (50 foot) 50 foot head. The temperature bulb shall be for pipeline insertion with 20 mm (3/4 inch) 3/4 inch NPT connector. Necessary appurtenances including bypass valve and combination temperature-pressure relief valve shall be provided.

d. Domestic Water Heater Control Valve: A thermostatic control valve shall be installed to operate in conjunction with a remote bulb temperature controller. The valve operating range shall be 38 to 70 degrees C (100 to 160 degrees F) 100 to 160 degrees F and valve shall be adjustable and modulate the flow of HTW to the heater between these temperatures. The valve shall have a cast steel body with stainless steel trim and lubricated deep-type stuffing box with packing suitable for the temperature and pressure conditions. The valve shall be single-seated, [_____] body to pass [_____] kg per second ([_____] pounds per hour) [_____] pounds per hour of HTW at a maximum pressure drop of 15 m (50 foot) 50 foot head. The temperature bulb shall be for pipeline insertion with 20 mm (3/4 inch) 3/4 inch NPT connector. Necessary appurtenances including bypass valve, strainer, and combination temperature-pressure relief valve shall be provided.

2.19.8 Back Pressure Relief Valves

Back pressure relief valves shall have steel bodies and shall be equipped with corrosion resistant trim and valve seats. The valves shall be properly guided and shall be positive closing so that no leakage can result. Adjustment of the desired back pressure shall cover the range between 13 to 70 kPa (2 to 10 psig). 2 to 10 psig. The adjustment shall be made externally and any shafts extending through the valve body shall be provided with adjustable stuffing boxes having renewable packing.

2.19.9 Exhaust Heads

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

2.19.10 Strainers

The strainer body connections shall be the same size as the pipelines in which the connections are installed. The strainer bodies shall be heavy and durable cast steel. 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 0.063 mm (0.0025 inch) 0.0025 inch thick stainless steel with enough small perforations to provide a net free area through the basket of at least 3.30 times that of the entering pipe. The flow shall be into the basket and out through the perforations.

2.19.11 Pipe Hangers, Inserts, and Supports

Pipe hangers, inserts, and supports shall conform to MSS SP-58 and MSS SP-69, except as modified herein.

2.19.11.1 Types 5, 12, and 26

Types 5, 12, and 26 shall not be used.

2.19.11.2 Type 3

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.

2.19.11.3 Type 18

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.

2.19.11.4 Types 19 and 23

Types 19 and 23 C-clamps shall be torqued per MSS SP-69 and have both locknuts and retaining devices furnished by the manufacturer. Field-fabricated C-clamp bodies or retaining devices are not acceptable.

2.19.11.5 Type 20

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

2.19.11.6 Type 24

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

2.19.11.7 Type 39 Saddle or Type 40 Shield

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) 4 inches and larger.

2.19.11.8 Horizontal Pipe Supports

Horizontal pipe supports shall be spaced as specified in MSS SP-69 and a support shall be installed not over 300 mm 1 foot from the pipe fitting joint at each changes 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 m 1/8 inch shall be provided between the pipe and clip or clamp for all piping which may be subjected to thermal expansion.

2.19.11.9 Vertical Pipe Supports

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.

2.19.11.10 Type 35 Guides with Slides

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.

a. 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) 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), 4 inches, a Type 40 protection shield may be attached to the pipe or insulation and freely rest on a steel slide plate.

b. 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), 4 inches, or by an amount adequate for the insulation, whichever is greater.

2.19.11.11 Pipe Hangers on Horizontal Insulated Pipes

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

2.19.11.12 Piping in Trenches

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NOTE: Detail of piping supported in trenches will be shown on the drawings.

****

Piping in trenches shall be supported as indicated.

2.20 INSULATION

Shop and field applied insulation shall be as specified in Section 15080A THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.21 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.

2.21.1 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.

2.21.2 Firing Tools

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

2.21.3 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 boiler manholes and handholes, for pump barrels, and other similar items of equipment. Gaskets shall be packaged and properly identified.

2.22 FUEL OIL TANKS

2.22.1 Fuel-Oil Storage Tanks

Storage tanks shall be constructed in accordance with Section 13202 FUEL STORAGE SYSTEMS.

2.22.2 Hot-Water Coil

Coil constructed of 1 inch seamless steel tubing shall be provided in each tank for No. 6 fuel oil and installed around the suction end of the oil line. Coil in each tank shall have capacity to heat from [_____] to [_____] degrees C ([_____] to [_____] degrees F), [_____] to [_____] degrees F, the maximum demand of all oil burners connected to the tank when supplied at 115 degrees C (240 degrees F). 240 degrees F. Heater shall be provided with automatic temperature-control valve, with strainer and three-valve by-pass in heated water supply line, and with check valve and cutoff valve in return line. An additional manhole located above the heater shall be provided for removal of the heater as a unit.

2.22.3 Tank Accessories

Accessories shall comply with Section 13202 FUEL STORAGE SYSTEMS.

2.23 COAL HANDLING EQUIPMENT

2.23.1 Screw Conveyor

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

Screw conveyor for the lateral distribution of coal shall consist of steel screw conveyor with capacity of not less than [_____] cubic meters per second ([_____] cubic feet per hour) [_____] cubic feet per 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 3.6 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) 3/16 inch steel with a 1.897 mm (14 gauge) 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.

2.23.2 Belt Conveyor

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

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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. Idlers and return rolls shall be CEMA Belt Book. Pressure lubrication shall be provided to ball or roller bearings. Idlers shall be 20-degree or 35-degree three-roll type spaced on 1200 mm 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 Conveyor and Elevator Belt Technical Information. 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 1.1 m 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 1200 mm 48 inches and larger shall be belt width plus 150 mm. 6 inches. Drive pulleys shall be provided with 20 mm 3/4 inch thick vulcanized and grooved lagging. Snub pulleys shall be provided with 9.5 mm (3/8 inch) 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] [water-tight] [dust-tight] [explosion-proof] enclosure.] 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 takeups, belt cleaners, skirt boards, and pulley scrapers. Dust controlling covers and inlet and discharge enclosures shall be provided for each conveyor.

2.23.3 Flight Conveyor

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

[Scraper] [Shoe-suspended] flight conveyor arranged generally as shown and of the single-strand type shall have capacity not less than [_____] metric tons per hour ([_____] tons per hour) [_____] tons per hour when handling coal with approximate weight of 800 kg per cubic meter (50 pcf) 50 pcf and with maximum lump size of [_____] mm ([_____] inches) [_____] inches diameter. Capacity shall be based on a maximum speed of 508 mm per second (100 fpm) 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 takeup with adjustment of not less than 300 mm. 12 inches. Trough shall be made of 4.8 mm (3/16 inch) 3/16 inch steel plate, minimum. All sliding surfaces in contact with the chain or flights shall be lined with 20 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.

2.23.4 Bucket Elevators

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

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 per hour ([_____] tons per hour) [_____] tons per hour when handling coal weighing approximately 800 kg per cubic meter (50 pcf). 50 pcf. Linear velocity shall be as indicated below:

Type of Bucket Elevator	Linear Velocity (meters per second)
Centrifugal discharge	1.1-1.6
Continuous bucket	0.51-0.69
Positive discharge	0.61 Max

Type of Bucket Elevator	Linear Velocity (fpm)
Centrifugal discharge	225-305
Continuous bucket	100-135
Positive discharge	120 Max

The head shaft and foot shaft shall be constructed of cold-rolled steel with the shaft diameters in accordance with manufacturer's standards. Both shafts shall be mounted in roller bearings with forced-type lubricating fittings. Foot shaft shall have screw takeup 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) 3/16 inch thick, minimum. Other flat casing members shall be 2.657 mm (12 gauge) 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.

2.23.5 Vibrating Conveyor

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

Vibrating conveyor shall be the electric-motor driven mechanical vibrating type with a capacity of [_____] metric tons per hour ([_____] tons per hour) [_____] tons per hour when handling coal weighing approximately 800 kg per cubic meters (50 pcf) 50 pcf and with maximum lump size of [_____] mm ([_____] inches) [_____] inches in diameter. Conveyor shall have a conveying length as shown. The conveyor trough shall be fabricated of [_____] mm ([_____] gauge) [_____] gauge steel, [_____] mm ([_____] inches) [_____] inches in width and [_____] mm ([_____] inches) [_____] inches deep [and provided with dust-tight cover]. Conveyor pans of 9.5 mm (3/8 inch) 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.]

2.23.6 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 per hour ([_____] tons per hour). [_____] tons per 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. The weigh feeders 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 conform to the RMA IP-1, fire-resistant type conforming to the standards of 30 CFR 1 Schedule 28, Part 34 of the MSHA. Top belt cover thickness shall be 6 mm 1/4 inch with bottom cover 3 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 RMA IP-1, Grade 2 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.

2.23.7 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) [_____] 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 A 36/A 36M mild steel, minimum 6 mm 1/4 inch thick with replaceable liners 6 mm 1/4 inch thick, ASTM A 167, 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 AREMA Manual 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 [_____] mm ([_____] inches) by [_____] mm ([_____] inches), [_____] by [_____] inches, and cross rods [_____] mm ([_____] inches) [_____] inches in diameter, to form openings [_____] mm ([_____] inches) [_____] inches square.

2.23.7.1 Rack-and-Pinion Gate

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) 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 mm 1/8 inch thick, ASTM A 167, Type 304L stainless steel. The gate body material, except for the dust cover, shall be of 4.8 mm (3/16 inch) 3/16 inch thick ASTM A 167, Type 304L stainless steel where in contact with coal flow.

2.23.7.2 Vibrating or Belt Feeders

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

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.]

2.23.8 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) [_____] tons and shall be constructed of 9.5 mm (3/8 inch) 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) 1/4 inch angles, minimum. The hopper may also be of ASTM A 36/A 36M mild steel, minimum 6.4 mm (1/4 inch) 1/4 inch thick with replaceable liners 6.4 mm (1/4 inch) 1/4 inch thick, ASTM A 167, 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 [_____] mm ([_____] inch) by [_____] mm ([_____] inch) [_____] by [_____] inch mild steel bars and [_____] mm ([_____] inches) [_____] inch diameter cross rods to form openings [_____] mm ([_____] inches) [_____] inches square. A supporting beam not less than [_____] mm ([_____] inches) [_____] inches deep, [_____] kg per meter ([_____] pounds per foot), [_____] pounds per foot, in a wide flange member, shall be provided under the grating.

2.23.8.1 Rack-and-Pinion Gate

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) 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) 1/8 inch thick, ASTM A 167, Type 304L stainless steel. The gate body material, except for the dust cover, shall be of 4.8 mm (3/16 inch) 3/16 inch thick ASTM A 167, Type 304L stainless steel where in contact with coal flow.

2.23.8.2 Vibrating or Belt Feeders

****

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

****

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.]

2.23.9 Vibrator

****

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

****

Vibrator shall be electromagnetic type with variable power control that produces mechanical pulsating motion. The net weight of the vibrator shall be [_____] kg ([_____] pounds) [_____] 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 seminoiseless 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.

2.23.10 Car Heaters

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NOTE: The designer will 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.
****

2.23.10.1 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). 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 Z83.6 and UL 795.

2.23.10.2 Electric Infrared Radiant Heaters

Electric infrared radiant heaters shall be weatherproof car thawing equipment with radiating surfaces of alloy tubing enclosing electrically insulated conductors. Heaters shall be designed for hazardous area locations. The equipment shall be in modular lengths suitable for both 45 metric tons (50 tons) 50 ton and 90 metric tons (100 tons) 100 ton 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.

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

Coal spouts, chutes, inlet boxes, and outlet hoppers shall be constructed of ASTM A 36/A 36M steel members not lighter than 3.416 mm (10 gauge), 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) [_____] inches thick, conforming to ASTM A 167, Type 304L]. Rack-and-pinion gates shall be of the type specified for track hoppers.

2.23.12 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), [_____] 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 23 kN (5,000 pounds), 5000 pounds, a running pull of 11 kN (2500 pounds), 2500 pounds, and an average rope speed not in excess of 230 mm per second (45 fpm). 45 fpm. The unit shall be complete with [_____] m ([_____] feet) [_____] feet of [32 mm (1-1/4 inch) 1-1/4 inch diameter manila rope with a breaking strength of 60 kN (13,500 pounds), 13,500 pounds, minimum,] [20 mm (3/4 inch) 3/4 inch diameter marline-covered standard steel wire rope with a breaking strength of 170 kN (37,600 pounds), 37,600 pounds, minimum,] and a steel car pulling hook with an allowable rope pull of 45 kN (10,000 pounds), 10,000 pounds, so fabricated as to be readily attachable to, and removable from, the car frames.

2.23.13 Coal Bunkers

Suspension coal bunkers of size and capacity indicated shall be constructed of ASTM A 36/A 36M 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 A 167, Type 304L 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.

2.23.14 Coal Storage Silos

2.23.14.1 Silo Walls

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 03300A CAST-IN-PLACE STRUCTURAL 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 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) 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) 3/8 inch steel.

2.23.14.2 Concrete Stave Silo

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.

2.23.14.3 Exteriors of Stave And Concrete Silos

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.

2.23.14.4 High- and Low-Level Switch

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.

2.23.15 Coal Crusher

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

The designer shall select the appropriate type of crusher, based on the throughput requirements and an economic analysis.

****

Coal crusher shall be [roll crusher] [hammermill] maximum lump size of [_____] mm ([_____] inches). [_____] inches. Crusher shall have a minimum capacity of [_____] metric tons per hour ([_____] tons per hour) [_____] tons per 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.]

2.23.16 Vibrating Feeders

Vibrating feeders shall be the [electro-magnetic] [electro-mechanical] [single input (Brute Force)] type with a capacity of 0 to [_____] metric tons per hour ([_____] tons per hour) 0 to [_____] tons per hour when handling coal weighing approximately 800 kg per cubic meter (50 pcf) 50 pcf and with maximum lump size of [_____] mm ([_____] inches) [_____] inches in diameter. Feeder pans and skirts shall be of replaceable [6.4] [9.5]

[12.7] mm ([1/4] [3/8] [1/2] inch) [1/4] [3/8] [1/2] inch thick, Type 304 solid stainless steel plate without liners. The feeder pan shall be fabricated [_____] mm ([_____] inches) [_____] inches in width, [_____] mm ([_____] inches) [_____] inches in length, and [_____] mm ([_____] inches) [_____] inches deep. Dust control covers of 3.416 mm (No. 10 gauge) 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) 1/4 inch thick Type 304L 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].

2.23.17 Tripper

The tripper shall be of steel construction, motor propelled, automatically reversible, or manually controlled. The tripper 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 per second (25 fpm), 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) [_____] 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 push-button stations shall be mounted, one on each side of the tripper. Both stations shall include forward-reverse and tripper stop-run push buttons. 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.

2.23.18 Trackmobile

Trackmobile shall be provided with a [_____] liter ([_____] cubic inch) [_____] 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) [_____] 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 per hour (mph) (mph) low [_____], high [_____]; on road, low [_____], high [_____]. The trackmobile shall be able to operate on a maximum grade of [_____] percent and minimum curve of [_____] 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, back-up alarm, [enclosed cab] [open cab] with windshield wipers [,radio remote control,] and power steering.

2.23.19 En-Masse Chain Conveyors

These conveyors 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 per hour ([_____] tons per hour) [_____] tons per hour when handling coal with approximate weight of 800 kg per cubic meter (50 pcf) 50 pcf and with maximum lump size of [_____] mm ([_____] inches) [_____] inches diameter. Maximum capacity shall be based on a chain speed not to exceed 800 mm per second (160 fpm). 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) 1/4 inch thick ASTM A 242/A 242M high strength, low alloy steel with 3.416 mm (No. 10 gauge) No. 10 gauge cover of the same material. The casing shall be provided with T-1 steel (ASTM A 514/A 514M, Type B) removable liners. The liners shall be 19.1 mm (3/4 inch) 3/4 inch thick on the bottom, and 12.7 mm (1/2 inch) 1/2 inch thick on the sides, 19.1 mm (3/4 inch) 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). 1/4 inch. Drive shaft shall be heat treated, designed and sized based on AGMA 6010 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 [handwheels] [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 supports and additional bracing as required for rigidity.

2.24 ASH HANDLING SYSTEM

2.24.1 Boiler Room Ash Handling System

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NOTE: When specifying boilers with capacity of 4.1 MW (14 million Btuh) or less per boiler, paragraph

Ash Hopper and subsequent paragraphs will be deleted, except applicable portions of paragraph Ash Silo through paragraph Rotary, Dustless Unloader will be retained.
****

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.

2.24.1.1 Ash Hopper

Ash removal hopper for each boiler shall be constructed of 6.4 mm (1/4 inch) 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 70 pcf.

2.24.1.2 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) [_____] 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) 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.

2.24.1.3 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 15 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 air-tight. 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. 4.6 Meter Fifteen foot lengths of vacuum hose with quick connectors and four floor sweep-up nozzles shall be provided.

2.24.1.4 Vacuum and Combination Vacuum/Pressure Systems

a. 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 per hour ([_____] tons per hour) [_____] tons per hour of ash weighing approximately [_____] kg per cubic meter ([_____] pcf). [_____] pcf. The tonnage shall be based on average handling rate and not on the instantaneous rate.

b. 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 per hour ([_____] tons per hour) [_____] tons per hour of ash weighing approximately [_____] kg per cubic meter ([_____] tons per hour). [_____] 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 per hour (50 tons per hour) 50 tons per hour per system.

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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, the portion included in the brackets shall be deleted. Air discharged to the atmosphere must meet the local air pollution standards.
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c. Pump Unit: 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.

d. 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.

e. 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.

f. 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.

2.24.1.5 Ash Silo

The ash storage silo shall have a capacity of not less than [_____] metric tons ([_____] tons) [_____] tons of ash and fly ash considered to have an average weight of [_____] kg per cubic meter ([_____] pcf). [_____] 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 per square meter ([_____] psf). [_____] 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). 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: 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 6.4 mm (1/4 inch) 1/4 inch steel plate with a tight-closing access door shall be provided as an enclosure for the discharger.

b. Silo Vent Filter: 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 kPa (100 psig) to 860 kPa (125 psig). 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 degrees C (minus 40 degrees F) to 55 degrees C (130 degrees F). minus 40 to 130 degrees F.

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

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c. Rotary, Dustless Unloader: 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) 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.]

2.24.1.6 Conveyor Type Ash Handling System

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NOTE: When specifying boilers with capacity greater than 4.1 MW (14 million Btuh) per boiler, this paragraph through paragraph Elevator Conveyor will be deleted.

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Ash pits shall be funnel shaped, constructed of 6.4 mm (1/4 inch) 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 per hour ([_____] tons per hour) [_____] tons per hour when handling ashes weighing approximately [_____] kg per meter ([_____] pcf) [_____] pcf at a maximum speed of 508 mm per second (100 fpm). 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.]

a. 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) [_____] inch pitch, [_____] mm ([_____] inch) [_____] inch overall width, and [_____] kg ([_____] pounds) [_____] 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) 3/8 inch cast-iron extending from [_____] mm ([_____] inches) [_____] inches in front of the foot shaft to [_____] mm ([_____] inches) [_____] 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) [_____] inch pitch roller chain and [_____] mm ([_____] inch) [_____] inch pitch diameter, [_____] tooth sprocket on the drive shaft, and a [_____] mm ([_____] inch) [_____] inch pitch diameter, [_____] -tooth sprocket on the elevator foot shaft.

b. Elevator Conveyor: Elevator conveyor shall be a single strand chain positive discharge type with head and takeup. The casing shall be constructed of 2.657 mm (12 gauge) 12 gauge steel, minimum, with 9.5 mm (3/8 inch) 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.

2.24.2 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 pushbuttons to start automatic operation of each system and also pushbuttons 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 electro-mechanical system. 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. 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.

2.24.3 Submerged Drag Chain Conveyor (SDCC)

Submerged drag chain conveyor shall be designed to extract ash at normal capacity [_____] metric tons per hour ([_____] TPH) [_____] TPH and maximum capacity [_____] metric tons per hour ([_____] TPH), [_____] TPH, based on a dry ash density of approximately [_____] kg per cubic meter ([_____] pcf). [_____] pcf. The maximum chain speed shall be 76 mm per second (15 fpm). 15 fpm. The SDCC shall be designed for continuous operation and shall have a storage capacity of [_____] cubic meters ([_____] cubic feet) [_____] cubic feet 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). 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) 3/8 inch thick carbon steel plate, welded construction, lined with renewable abrasion resistant steel wear plates, with a minimum thickness of 15 mm (1/2 inch) 1/2 inch and 380 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 [_____] meters. [_____] feet. The return chain bottom trough shall be dry, constructed of 9.5 mm (3/8 inch) 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 15 mm (1/2 inch) 1/2 inch thick steel replaceable wear flats with a minimum 300 BHN. Wear strips shall be also provided under the return flights, minimum 15 mm (1/2 inch) 1/2 inch thick and 50 mm 2 inches 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 500-630 BHN. Design strength and pitch shall be based on operating conditions. The conveyor flights shall be [_____] mm ([_____] inches) [_____] inches deep by [_____] mm ([_____] inches) [_____] 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. 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 sprays shall also be provided.

2.24.4 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 per hour ([_____] tons per hour) [_____] tons per hour of ash weighing approximately [_____] kg per cubic meter ([_____] pcf). [_____] pcf. Each transport vessel shall be bolted to the hopper discharge flange where ash shall flow into vessel by gravity until a level indicator indicates the vessel is full. The transport vessel inlet valve then closes, and transport air between 170 kPa to 345 (25 to 50 psi) 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) [_____] inches diameter. The material velocities in the transportation pipe shall be [_____] meters per second ([_____] fpm). [_____] fpm. The system shall be provided with 210 to 415 kPa (30 to 60 psi) 30 to 60 psi compressed air to fluidize the transmit ash. The conveying velocity shall not exceed 5 meters per second (1000 fpm). 1000 fpm.

2.24.5 Fly Ash Collectors

Fly ash collectors shall be as specified in Section 11500 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 ERECTION OF BOILER AND AUXILIARY EQUIPMENT

Boiler and auxiliary equipment shall be installed as indicated and in accordance with manufacturers' instructions.

3.2 EARTHWORK

Excavation and backfilling for tanks and piping shall be as specified in Section 02300 EARTHWORK, except backfill for fiberglass reinforced fuel tanks shall conform to the manufacturer's installation instructions.

3.3 STORAGE TANK INSTALLATION

Storage tank installation shall be in accordance with Section 13202 FUEL STORAGE SYSTEMS.

3.4 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. Piping shall be free of burrs, oil, grease, and other foreign matter. Piping 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) 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 A 53/A 53M, Grade A, standard, or Grade B extra-heavy weight. Vent pipes shall be carried through the roof 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) 2-1/2 inches or less in diameter and with flanges for pipe 80 mm (3 inches)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 HTW lines, reducing fittings shall be eccentric type to maintain the top of the lines at the same level.

3.4.1 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. 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, partitions, and floors shall be sealed as indicated and specified in Section 07920 JOINT SEALANTS and in fire rated walls, partitions, and floors shall be sealed as indicated and specified in Section 07840 FIRESTOPPING. Metal jackets shall be provided over insulation passing through exterior walls, fire walls, fire partitions, floors, or roofs, shall not be thinner than 152.4 micrometers (0.006 inch) 0.006 inch thick aluminum, if corrugated, and 0.4064 mm (0.016 inch) 0.016 inch thick aluminum, if smooth, and shall be secured with aluminum or stainless steel bands not less than 10 mm 3/8 inch wide and not more than 200 mm 8 inches apart. When penetrating roofs, before fitting the metal jacket into place, a 15 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 height 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.

3.4.1.1 Pipes Passing through Waterproofing Membranes

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NOTE: Typical details of pipe sleeves through walls, floors, and roofs are shown in TM 5-805-6. The applicable detail plates will be completed and included in the contract drawings.

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In addition to the pipe sleeves referred to above, pipes passing through roof or floor waterproofing membranes shall be provided with a 1.8 kg (4 pound) 4 pound lead flashing or a 453 g (16 ounce) 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.

3.4.1.2 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 utilizing standard roof coupling for threaded pipe up to 150 mm 6 inches in diameter; lead flashing sleeve for dry vents and turning the sleeve down into the pipe to form a waterproof joint; tack-welded or banded-metal rain shield around the pipe and sealing as indicated.

3.4.2 Pipe Joints

Joints between sections of pipe and fittings shall be welded or flanged on all HTW piping. On auxiliary piping, except as otherwise specified, fittings 25 mm (1 inch) 1 inch and smaller shall be threaded; fittings 32 mm (1-1/4 inches) 1-1/4 inches up to, but not including, 65 mm (2-1/2 inches) 2-1/2 inches may be either threaded or welded; and fittings 65 mm (2-1/2 inches) 2-1/2 inches and larger shall be either flanged or welded. Pipe and fittings 32 mm (1-1/4 inches) 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) 2 inches or smaller in diameter, and with flanges for pipe 65 mm (2-1/2 inches) 2-1/2 inches or larger in diameter.

3.4.2.1 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.

3.4.2.2 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.

a. 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.

b. Alignment: Before welding, the component 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. If tack welds are used, 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.

c. Erection: Where the temperature of the component parts being welded reaches 0 degrees C (32 degrees F) 32 degrees F or lower, the material shall be heated to approximately 38 degrees C (100 degrees F) 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). 32 degrees F.

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

e. 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.

3.4.2.3 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) 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.

3.4.3 Supports

3.4.3.1 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.

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Hangers used to support piping 50 mm (2 inches) 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. 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). 50 pounds. Loads exceeding 23 kg (50 pounds) 50 pounds shall be suspended from panel points.]

3.4.3.2 Seismic Requirements for Pipe Supports and Structural Bracing

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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 provided. Sections 13080 and 15070, properly edited, must be included in the contract documents.
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Piping and attached valves shall be supported and braced to resist seismic loads [as specified under Sections 13080 SEISMIC PROTECTION FOR MISCELLANEOUS EQUIPMENT and 15070A SEISMIC PROTECTION FOR MECHNICAL EQUIPMENT] [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 05120 STRUCTURAL STEEL.

3.4.3.3 Structural Reinforcements

Structural steel reinforcements required to support piping, headers, and equipment, but not shown, shall be provided under this section. Material and installation shall be as specified under Section 05120 STRUCTURAL STEEL.

3.4.4 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.

3.4.5 Pipe Expansion

3.4.5.1 Expansion Loop

****
NOTE: Wherever possible, provisions for expansion of supply-and-return pipes will be made by changes in the direction of the run of the pipe or by field fabricated expansion bends. Where restrictions in space prevent such provisions for expansion, expansion joints will be installed and blank will filled as appropriate. Bracketed portion will be deleted if inapplicable.
****

Expansion loop 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.

3.4.5.2 Expansion Joints

****
NOTE: If expansion joints are required, this paragraph will be deleted. Where restrictions in space prevent such provisions for expansion, expansion joints will be installed and blank will be

filled as appropriate. Bracketed portion will be deleted if inapplicable.
****

Expansion joints shall provide for either single or double slip of the connected pipes, as required and indicated, and for not less than the traverse indicated. Anchor bases or support bases shall be provided as indicated or required. Initial setting shall be made in accordance with the manufacturer's recommendation to allow for an 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 that in lines 100 mm (4 inches) 4 inches or smaller guides shall be installed not more than 600 mm 2 feet from the joint.

3.4.6 Valves

Gate valves and globe valves shall be installed with the stem horizontal or above. 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 always be installed in horizontal piping with the cap or bonnet up.

3.5 BURIED PIPING INSTALLATION

3.5.1 Protective Coating for Underground Steel Pipe

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. Field joints shall be coated and wrapped by hand. 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.

3.5.2 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. 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.

3.5.3 Coating Materials

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

3.5.3.1 Epoxy Coating System

The epoxy coating system shall conform to the AWWA C213. Fittings, valves, and joints shall be factory coated with materials identical to those used on the pipe, or may be field-coated with a 2-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.

3.5.3.2 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. Where excessively corrosive soils are encountered, the piping shall be given a second coating of coal-tar enamel and a second wrapper of felt.

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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 white-wash, 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. Joints and fittings shall be coated and wrapped.

3.5.3.3 Polyethylene Pipe Coating

Continuous extruded polyethylene coating and adhesive undercoat application procedure, including surface preparation, shall be a factory-applied system conforming to NACE RP0185, 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.

3.5.3.4 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). 0.020 inch. The tape shall conform to ASTM G 21 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), 4 inches, one layer half-lapped shall be used. For pipe 100 mm (4 inches) 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.

3.5.3.5 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. 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.

3.5.4 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 settling. 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 15 mm 1/2 inch between the pipe and sleeve, except where otherwise indicated. Sleeves through concrete may be 0.912 mm (20 gauge) 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 FIELD PAINTING AND COATING

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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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Except as otherwise specified, ferrous metal shall be cleaned, prepared, and painted as specified in Section 09900 PAINTS AND COATINGS. Buried steel shall be given a protective coating as specified. Exposed pipe covering shall be painted as specified in Section 09900 PAINTS AND COATINGS. Aluminum sheath over insulation shall not be painted.

3.7 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.

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3.7.1 Hydrostatic Tests

Following erection, each HTW generator shall be tested hydrostatically and proved tight under a gauge pressure of 1-1/2 times the specified working pressure. Following the installation of all piping and boiler house equipment, but before the application of any insulation, hydrostatic tests shall be made and the system proved tight under gauge pressures of 1-1/2 times the specified working pressure. Tests shall be made under the direction of, and subject to, the approval of the Contracting Officer. The Contractor shall adjust all equipment and controls before the scheduled operational test. A testing schedule shall be submitted at least 15 days before scheduled test.

3.7.1.1 Water Sides Including Fittings and Accessories

Water sides shall be hydrostatically tested in accordance with the requirements of ASME BPVC SEC I and ASME BPVC SEC VIII D1 as applicable. The ASME stamp will be accepted as evidence of this test.

3.7.1.2 Generator Casing, Air Casings, and Ducts

Air casing and ducts exterior to the generators shall be tested pneumatically at the maximum working pressure. The soap bubble or smoke bomb method shall be used to verify tightness. Gas sides of the generators normally operated under pressure shall be tested for tightness at 1-1/2 times the predicted operating pressure in the furnace at maximum predicted output. For this test the generator shall be tightly sealed with a suitable means to blank off all openings. Air shall be admitted to the generator until the test pressure is reached and then shall be held. If in a 10-minute period the pressure drop does not exceed 1.2 kPa (5 inches water gauge), 5 inches water gauge, the casing shall be regarded as tight and accepted. Air pressure and smoke bomb or comparative CO(2) readings shall be used for induced draft generators.

3.7.1.3 Fuel Oil Test

After the system has been flushed and operationally tested, the underground portion of the system shall be leak tested in accordance with Section 13202 FUEL STORAGE SYSTEMS.

3.7.1.4 Fuel Systems for Oil-Fired HTW Generators

The part of the preassembled fuel oil system that is furnished integrally with the generator shall be tested hydrostatically at 1-1/2 times the maximum operating pressure. The part of the preassembled gas system that is furnished integrally with the generator shall be tested pneumatically at operating pressure. The soap bubble test method shall be used to verify tightness of the gas system.

3.7.2 Fire Safety for Oil-Fired HTW Generators

Test shall be conducted as necessary to determine compliance with the applicable UL safety standards. The presence of the UL label may be accepted as evidence of compliance in this respect.

3.7.2.1 Oil-Fired Generators

Oil-fired generators shall meet the test requirements of UL 726.

3.7.2.2 Oil Burners

Oil burners shall meet the test requirements of UL 296.

3.7.3 Capacity and Efficiency Tests

The capacity and efficiency at the specified capacity of the generator shall be determined in accordance with the ASME PTC 4.1 for steam generating units. The efficiency shall be determined by the direct input-output method and shall be checked with the loss method computation. Test runs shall be made at the maximum capacity for 4 hours; at the minimum capacity and at 50 percent capacity for 2 hours each, respectively. Test reports and performance curves shall be submitted to the Contracting Officer. Before any operational tests are conducted, the system shall be correctly balanced within 5 percent of that indicated. Corrections and adjustments shall be made as necessary to produce the required conditions. Approved methods shall be used to measure all rates of flow. The efficiency and general performance tests on the boilers shall be conducted by a qualified test engineer furnished by the Contractor, and observed by a representative of the Contracting Officer. Testing apparatus shall be set up, calibrated, tested, and readied for testing the boiler before the arrival of the representative of the Contracting Officer. Calibration curves or test results furnished by an independent testing laboratory for each instrument, meter, gauge, and thermometer to be used in efficiency and capacity test 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. The analysis shall include all pertinent data tabulated in the ASME PTC 4.1 abbreviated efficiency test. The Contractor shall provide and install all necessary temporary piping valves, controls, heat exchanger, and cooling water provisions to provide a load for testing each HTW generator. If any system load is available, the Contracting Officer will provide for loading the heating system for the test, but full-load capability will probably require a supplementary heat exchanger for the test.

3.7.4 Operating Tests

After adjustment and achievement of stable operation of the HTW generators, each shall be tested continuously for 12 hours, minimum, to demonstrate control and operational conformance to the requirements of this specification under varying load conditions ranging from the specified capacity to the minimum burner or stoker turndown ratio without on-off cycling. In each case, the operating tests shall cover the periods for the capacities tabulated below:

Waterwall Watertube Boilers

Time (minimum)	Percent of Capacity
First 2 hours	50
Next 2 hours	75
Next 6 hours*	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 that specified.

3.7.5 Test of Fuel Burning Equipment

Automatic oil burners shall also be tested for capability to provide high temperature water in accordance with demand when on-off cycling is required. Fuel burning equipment that exhibits excessive or unexplained loss of ignition, nuisance shutdown due to faulty burner, stoker, or control operation, improper flame, excessive carbon deposits or slag, or necessity for difficult or frequent adjustments shall be rejected. Operational tests shall include the following as applicable to the type of HTW generator.

3.7.5.1 Sequencing

The HTW generator shall [start,] operate, and stop in accordance with the specified operating sequence.

3.7.5.2 Flame Safeguard

The operation of the flame safeguard control on oil- or gas-fired generators shall be verified by simulated flame and ignition failures. Burners having continuous or intermittent pilots shall be tested by simulating main flame failure while the pilot is burning. The trial-for-pilot ignition, trial-for-main-flame ignition, combustion control reaction, and valve closing times shall be verified by stop watch.

a. Immunity to Hot Refractory: The burner shall be operated at high fire until the combustion chamber refractory reaches maximum temperature. The main fuel valve shall then be closed manually. The combustion safeguard shall drop out immediately causing the safety shutoff valves to close within the specified control reaction and valve closing times.

b. Pilot Intensity Required: The fuel supply to the pilot flame shall be gradually reduced to the point where the combustion safeguard begins to drop out (sense "no flame") but holds in until the main fuel valve opens. At this point of reduced pilot fuel supply, the pilot flame shall be capable of safely igniting the main burner. If the main fuel valve can be opened on a pilot flame of insufficient intensity to safely light the main flame, the generator shall be rejected.

c. Turndown Ratio: The specified turndown ratio shall be verified by firing at the minimum firing rate.

d. HTW Generator Limit and Fuel Safety Interlocks: Safety shutdown shall be caused by simulating interlock actuating conditions for each generator limit and fuel and safety interlock. Safety shutdowns shall occur in the specified manner.

e. Combustion Controls: 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.

f. Safety Valves: Safety valves on HTW generators shall not be tested under operating conditions.

g. Blowdown Valves and Try Cocks: Blowdown valves and try cocks shall be tested for proper operation.

h. Fans, Heaters, Pumps, and Motors: Draft fans, fuel oil heaters, fuel pumps, and electric motors shall be tested when necessary to determine compliance with the referenced standards. The operation of fans, [fuel oil heaters] [stokers] [fuel pumps] and electric motors shall be closely observed for possible defects or nonconformance.

3.7.6 Test of Water Treatment Equipment

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

3.7.7 System Balancing

During operating tests, the preliminary system balancing results shall be observed and flow rates logged. Where an auxiliary heat exchanger is not required for the test load, final system balancing shall be accomplished during the operating test. Where the auxiliary heat exchanger is required, sufficient temporary piping shall be provided to shunt the water flow through the various system control valves to allow an approximate flow balance of the system.

3.8 CLEANING OF HTW GENERATORS AND PIPING

3.8.1 HTW Generator Cleaning

After the hydrostatic tests have been made, and before performance of the operating tests, the boilers shall be thoroughly and effectively 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. HTW generators shall be filled with a solution consisting of the following proportional ingredients for every 3785 liters (1000 gallons) 1000 gallons of water, and operated at approximately 210 kPa to 345 kPa (30 to 50 psig) 30 to 50 psig for a period of 24 to 48 hours:

11 kg caustic soda; 24 lb. caustic soda; 3.6 kg sodium nitrate;8 lb. sodium nitrate; 11 kg disodium phosphate, anhydrous; 24 lb. disodium phosphate, anhydrous; and 230 g approved wetting agent.1/2 lb. approved wetting agent.

Chemicals in the above proportions, or as otherwise approved, shall be thoroughly dissolved in the water before being placed in the HTW generator. 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 HTW generators for a period of approximately 48 hours.

3.8.2 HTW Generator Water Conditioning

The Contractor shall provide HTW generator water conditioning including chemicals, chemical treatment, and blowdown during periods of boiler operation to prevent scale and corrosion in HTW generators 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.

3.9 MANUFACTURER'S SERVICES

Services of a manufacturer's representative who is experienced in the installation, adjustment, and operation of the equipment specified shall be provided. The representative shall supervise the installing, adjusting, and testing of the equipment.

3.9.1 Field Training

A field training course shall be provided 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.

3.10 SCHEDULES

TABLE I. PIPE

Service	Pressure kPa	Material	Specification	Type
Boiler feed, drain lines, & HTW lines	0-4150	Black steel (2)	ASTM A 53/A 53M	Type E Grade A
Feedwater piping	0-860	Std. wt. black steel	ASTM A 53/A 53M	Type E Grade A
Cold water piping	0-860	Std. wt. zinc-coated	ASTM A 53/A 53M	Type E Grade A
Water column (1)	0-4150	Std. wt. black steel	ASTM A 53/A 53M	Type E Grade A
Vent and exhaust	0-175	Std. wt. black pipe steel	ASTM A 53/A 53M	Type E Grade A
Compressed air	0-860	Std. wt. black steel	ASTM A 53/A 53M	Type E Grade A
Gauge piping ASTM B 88M Type K	0-175	Copper tubing	ASTM B 88, or L	
	0-4150	Black steel (2)	ASTM A 53/A 53M	Type E Grade A
Fuel oil (Nos. 4, 5, & 6)	0-1050	Std. wt. black steel	ASTM A 53/A 53M	Type E Grade A
Control air	0-1050	Copper tubing Std. wt. black steel	ASTM B 68MASTM B 68 ASTM A 53/A 53M	[_____] Type E Grade A

TABLE I. PIPE

Service	Pressure	Material	Specification	Type
Boiler feed, drain lines, & HTW lines	0-600	Black steel (2)	ASTM A 53/A 53M	Type E Grade A
Feedwater piping	0-125	Std. wt. black steel	ASTM A 53/A 53M	Type E Grade A
Cold water piping	0-125	Std. wt. zinc-coated	ASTM A 53/A 53M	Type E Grade A
Water column (1)	0-600	Std. wt. black steel	ASTM A 53/A 53M	Type E Grade A
Vent and exhaust	0-25	Std. wt. black pipe steel	ASTM A 53/A 53M	Type E Grade A

TABLE I. PIPE

Service	Pressure	Material	Specification	Type
Compressed air	0-125	Std. wt. black steel	ASTM A 53/A 53M	Type E Grade A
Gauge piping ASTM B 88M Type K	0-25	Copper tubing	ASTM B 88, or L	
	0-600	Black steel (2)	ASTM A 53/A 53M	Type E Grade A
Fuel oil (Nos. 4, 5, & 6)	0-150	Std. wt. black steel	ASTM A 53/A 53M	Type E Grade A
Control air	0-150	Copper tubing	ASTM B 68MASTM B 68	[_____]
		Std. wt. black steel	ASTM A 53/A 53M	Type E Grade A

Note 1: No bending of pipe will be permitted. Crosses with pipe plugs at connection shall be provided.

Note 2: Extra Strong (XS) minimum weight. Conform to ASME B31.1 for wall thickness.

TABLE II. FITTINGS

Service	Size	Title	Materials	Specification
Vent pipe	Under 80 mm	Threaded	Malleable-iron	ASME B16.3
	80 mm & larger	Buttwelded	Steel	ASME B16.9
Compressed air	Under 80 mm	Threaded	Zinc-coated malleable-iron	ASME B16.3
Exhaust pipe	Under 80 mm	Threaded	Zinc-coated malleable-iron	ASME B16.3
	80 mm & larger	Buttwelded	Steel	ASME B16.9
Boiler feed (1)	Under 80 mm	Threaded	Malleable-iron	ASME B16.3
	80 mm & larger	Buttwelded	Steel	ASME B16.9
Feedwater pipe	Under 80 mm	Threaded	Malleable-iron	ASME B16.3
	80 mm & larger	Buttwelded	Steel	ASME B16.9
Drain lines (1) & HTW lines	All	Buttwelded	Steel	ASME B16.9
		Socket welded	Steel	ASME B16.11
		Flanged with long radius elbows	Steel	ASME B16.5

TABLE II. FITTINGS

Service	Size	Title	Materials	Specification
Water column piping (1)	Under 80 mm	Threaded	Malleable-iron	ASME B16.3
Gauge pipe	All	Flared or soldered	Cast or wrought bronze	ASME B16.18 ASME B16.26

TABLE II. FITTINGS

Service	Size	Title	Materials	Specification
Vent pipe	Under 3-inches 3-inches & larger	Threaded Buttwelded	Malleable-iron Steel	ASME B16.3 ASME B16.9
Compressed air	Under 3-inches	Threaded	Zinc-coated malleable-iron	ASME B16.3
Exhaust pipe	Under 3-inches 3-inches & larger	Threaded Buttwelded	Zinc-coated malleable-iron Steel	ASME B16.3 ASME B16.9
Boiler feed (1)	Under 3-inches 3-inches & larger	Threaded Buttwelded	Malleable-iron Steel	ASME B16.3 ASME B16.9
Feedwater pipe	Under 3-inches 3-inches & larger	Threaded Buttwelded	Malleable-iron Steel	ASME B16.3 ASME B16.9
Drain lines (1) & HTW lines	All	Buttwelded Socket welded Flanged with long radius elbows	Steel Steel Steel	ASME B16.9 ASME B16.11 ASME B16.5
Water column piping (1)	Under 3-inches	Threaded	Malleable-iron	ASME B16.3
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 except minimum shall be extra strong pipe. Match piping requirements.

Note 2: Fuel oil piping and fittings shall comply with Section 13202 FUEL STORAGE SYSTEMS.

-- End of Section --