Preparing Activity: USACE Superseding without Revision
UFGS-23 70 01.00 10 (January 2008)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023
****

SECTION TABLE OF CONTENTS

DIVISION 23 - HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)

SECTION 23 52 30.01 10

CENTRAL COAL-FIRED STEAM-GENERATING SYSTEM

05/20

PART 1 GENERAL

1.1 REFERENCES
1.2 SUBMITTALS
1.3 QUALITY ASSURANCE
1.3.1 Welding
1.3.2 Use of Asbestos Products
1.4 DELIVERY, STORAGE, AND HANDLING
1.5 EXTRA MATERIALS

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT
2.1.1 Standard Products
2.1.2 Nameplates
2.1.3 Prevention of Rust
2.1.4 Equipment Guards and Access
2.2 BOILERS
2.2.1 Capacity
2.2.2 Electrical Equipment
2.2.2.1 Motor Ratings
2.2.2.2 Motor Starters
2.2.3 Boiler Design Requirements
2.2.3.1 Radiant Heating
2.2.3.2 Heat Input
2.2.3.3 Combustion Gas
2.2.3.4 Ash Discharge
2.2.3.5 Radiant Heating Surface
2.2.3.6 Furnace Volume
2.2.3.7 Boiler Operating Capacity
2.2.3.8 Boiler Output Capacity
2.2.3.9 Boiler Markings
2.3 BOILER DETAILS
2.3.1 Packaged Steam-Generating Units

2.3.1.1 Firebox Type (for Boiler Capacities Less Than 2.9 Mega watts 10,000,000 Btuh)
2.3.1.2 Watertube, Waterwall Type (Boiler Capacities Over 2.9 Mega watts 10,000,000 Btuh)
2.3.2 Watertube Boilers
2.3.2.1 Drums
2.3.2.2 Tubes
2.3.2.3 Baffles
2.3.2.4 Access Doors
2.3.2.5 Miscellaneous Pipe Connections
2.3.2.6 Superheater Design
2.3.2.7 Boilers and Firing Equipment
2.3.3 Boiler Settings
2.3.3.1 Boiler Material
2.3.3.1.1 Firebrick
2.3.3.1.2 Insulating Brick
2.3.3.1.3 Castable Refractory
2.3.3.1.4 Mortar, Air-Setting, Refractory
2.3.3.1.5 Brick, Common
2.3.3.1.6 Galvanized Steel Sheets
2.3.3.1.7 Uncoated Steel Sheets and Strips, Low Carbon
2.3.3.2 Firebox, Packaged Type
2.3.3.3 Watertube, Waterwall Type
2.3.3.3.1 Boiler Roof
2.3.3.3.2 Bridge Walls
2.3.3.3.3 Settling Chamber
2.3.3.3.4 Expansion Joints
2.3.3.3.5 Firebrick
2.3.3.3.6 Plastic Refractory
2.3.3.4 Watertube, Waterwall (Packaged Type) Unit
2.3.4 Boiler Fittings and Appurtenances
2.3.4.1 Water column
2.3.4.2 Water Gauge
2.3.4.3 Low Water Cutoff
2.3.4.4 Bypass Button
2.3.4.5 Steam Gauge
2.3.4.6 Feed and Check Valves
2.3.4.7 Continuous Blowdown Valve
2.3.4.8 Safety Valves
2.3.4.9 Blowoff Valves
2.3.4.10 Steam Nonreturn Valve
2.3.4.11 Feedwater Regulator
2.3.4.12 Soot Blowers
2.4 STOKER EQUIPMENT
2.4.1 Spreader Stokers
2.4.1.1 Spreader Stoker Grates
2.4.1.2 Traveling Grates
2.4.1.3 Vibrating Grate
2.4.1.4 Stoker Controls
2.4.1.5 Hoppers
2.4.1.6 Over-Fire Turbulence and Cinder and Dust Reinjection System
2.4.2 Underfeed Stokers
2.4.2.1 Single Retort, Heavy-Duty Ram-Type Stokers
2.4.2.1.1 Grate Surface
2.4.2.1.2 Ram Feed
2.4.2.1.3 Hoppers
2.4.2.2 Single Retort Screw Type Stokers
2.4.3 Conveyor Stokers
2.4.3.1 Grates

2.4.3.2 Grate Operation
2.4.3.3 Hoppers
2.4.4 Vibrating Grate Stokers
2.4.4.1 Grates
2.4.4.2 Stoker Controls
2.4.4.3 Hoppers
2.5 PULVERIZED COAL BOILERS
2.5.1 Coal Pulverizers
2.5.2 Burners
2.5.3 Furnace Ash System
2.5.4 Pulverizer Rejects
2.5.5 Control Systems
2.5.5.1 Coal Master Control System
2.5.5.2 Primary Air
2.5.5.3 Air Temperature Control
2.5.5.4 Flame Safety System
2.6 FLUIDIZED BED COMBUSTION BOILERS
2.6.1 General
2.6.2 Furnace and Boiler
2.6.3 Forced Circulation System
2.6.4 In-Bed Tube Surface (AFB Designs)
2.6.5 Coal and Sorbent Feed Systems
2.6.5.1 AFB Coal Feed System
2.6.5.2 CFB Coal Feed Systems
2.6.6 Fluidized Bed Combustion Area
2.6.7 Bed Material Letdown System
2.6.8 Burners and Fuel Piping
2.6.9 Air Distribution System
2.6.10 Mechanical Collector and Solids Recycle System for AFB Boilers
2.7 IGNITION OIL SYSTEM
2.7.1 Ignition Oil Pumps
2.7.2 Burners
2.7.3 Aboveground Oil Storage Tanks
2.7.4 Underground Oil Storage Tanks
2.8 COMBUSTION CONTROL EQUIPMENT
2.8.1 Positioning Type
2.8.2 Metering Type Combustion Control Equipment
2.8.2.1 Fuel-Flow, Air-Flow Type Combustion Control
2.8.2.2 Two Element (Steam Pressure, Steam Flow)
2.8.2.2.1 Master Pressure Transmitter
2.8.2.2.2 [Fuel Feed] [Steam-Flow] Transmitter
2.8.2.2.3 Air-Flow Transmitter
2.8.2.2.4 Automatic Controller
2.8.2.2.5 Power Units
2.8.2.2.6 Furnace Draft Controller
2.8.3 Combustion Controls with Oxygen Trim
2.8.4 Boiler Limit Controls
2.8.5 Burner Control/Fuel Safety System
2.8.5.1 Design Requirements
2.8.5.1.1 Maintenance and Reliability Requirements
2.8.5.1.2 Adverse Electrical Conditions
2.8.5.2 System Design
2.8.5.3 System Functional Requirements
2.8.5.3.1 Operating Modes
2.8.5.3.2 Furnace Purge and Boiler Monitor
2.8.5.3.3 Mill Start-Stop Sequences
2.8.5.3.4 Ignitor Control
2.8.5.3.5 Fuel Safety Subsystem
2.8.5.3.6 Flame Monitoring

2.8.5.3.7 Enclosures
2.8.5.3.8 Local Termination Boxes
2.8.5.3.9 Interconnecting Cable Requirements
2.8.5.3.10 Buffered Output Signals
2.9 BOILER ROOM PANELS AND INSTRUMENTS
2.9.1 Instrument Control Panel
2.9.2 Indicators
2.9.3 Recorders
2.9.4 Panel Display
2.9.5 Panel Piping and Wiring
2.9.6 Pilot Lights
2.9.7 Clock
2.9.8 Alarm Annunciator Panel
2.9.9 Combustion Control Components
2.9.10 Steam and Feedwater Flow Measurement
2.9.11 Flue Gas Opacity Monitor
2.9.12 Sample Cooler
2.9.13 Oxygen Analyzer
2.9.14 Continuous Blowdown
2.9.15 Continuous Emissions Monitoring
2.10 WASTE HEAT RECOVERY EQUIPMENT
2.10.1 Economizers
2.10.2 Air Preheaters
2.11 DRAFT FANS
2.11.1 Draft Fan Control
2.11.2 Draft Fan Drives
2.12 AIR DUCTS
2.13 BREECHING
2.14 STACKS
2.15 BLOWOFF TANK
2.16 PUMPS
2.16.1 Boiler Feed Pumps
2.16.1.1 Casings
2.16.1.2 Base
2.16.1.3 Couplings
2.16.1.4 Automatic Recirculation
2.16.1.5 Turbines
2.16.1.6 Electric Motors
2.16.1.7 Shop Hydrostatic Testing
2.16.2 Condensate Pumps
2.17 CONDENSATE TANK AND ACCESSORIES
2.17.1 Condensate Tank
2.17.2 Feedwater Makeup Valve
2.18 HEAT EXCHANGERS
2.19 DEAERATING FEEDWATER HEATER
2.20 STEAM TRAPS
2.20.1 Bucket Traps
2.20.2 Impact-Operated Traps
2.20.3 Thermostatic Traps
2.20.4 Float and Thermostatic Traps
2.21 PRESSURE GAUGES
2.22 THERMOMETERS
2.23 WATER METER
2.24 CHEMICAL TREATMENT AND WATER SOFTENING EQUIPMENT
2.24.1 Chemical Feeder
2.24.2 Water Softening Equipment
2.24.2.1 Water Analysis
2.24.2.2 Zeolite
2.24.2.3 Reactor Tank

2.24.2.4 Softening System
2.24.2.5 Water Test Kit
2.24.2.6 Treated Water Storage Tank
2.25 BUILDING HEATING EQUIPMENT
2.25.1 Unit Heaters
2.25.1.1 General
2.25.1.2 Propeller Type Unit Heater
2.25.1.3 Cabinet Unit Heaters
2.25.1.4 Heating Elements
2.25.1.5 Manual Selection Switches
2.25.1.6 Automatic Operation
2.25.1.6.1 Thermostatic Control by Fan Regulation
2.25.1.6.2 Thermostatic Control by Steam Valve Regulation
2.25.2 Radiator and Convector
2.26 AIR COMPRESSOR UNITS
2.26.1 Service Air Compressors
2.26.2 Instrument Air Compressors
2.27 PIPING
2.27.1 Pipe
2.27.2 Fittings
2.27.3 Nipples
2.27.4 Unions
2.27.5 Pipe Threads
2.27.6 Expansion Joints
2.27.6.1 Guided, Slip-Tube Type Expansion Joints
2.27.6.2 Bellows Type Expansion Joints
2.27.6.3 Flexible Ball Type Expansion Joints
2.27.7 Valves
2.27.7.1 Check Valves
2.27.7.2 Gate Valves
2.27.7.3 Globe Valves and Angle Valves
2.27.7.4 Steam Pressure Reducing Valves
2.27.7.5 Thermostatic Regulating Valves
2.27.7.6 Back Pressure Relief Valves
2.27.7.7 Boiler Automatic Feedwater Recirculating Control Valve
2.27.8 Exhaust Heads
2.27.9 Strainers
2.27.10 Pipe Hangers, Inserts, and Supports
2.28 INSULATION
2.29 TOOLS
2.29.1 Tube Brush
2.29.2 Smoke Pipe Cleaner
2.29.3 Firing Tools
2.29.4 Wrenches and Gaskets
2.30 COAL HANDLING EQUIPMENT
2.30.1 Screw Conveyor
2.30.2 Belt Conveyor
2.30.3 Flight Conveyor
2.30.4 Bucket Elevators
2.30.5 Vibrating Conveyor
2.30.6 Gravimetric Weigh Feeder
2.30.7 Track Hoppers
2.30.7.1 Hopper Gates
2.30.7.2 Hopper Feeders
2.30.8 Truck Hoppers
2.30.8.1 Hopper Gates
2.30.8.2 Hopper Feeders
2.30.9 Vibrator
2.30.10 Car Heaters

2.30.10.1 Gas-Fired Heaters
2.30.10.2 Electric Infrared Radiant Heaters
2.30.11 Coal Spouts, Chutes, Inlet Boxes, and Outlet Hoppers
2.30.12 Car Spotter
2.30.13 Coal Bunkers
2.30.14 Coal Storage Silos
2.30.14.1 Silo Design
2.30.14.2 Silo Interior Finish
2.30.14.3 Silo Exterior Finish
2.30.14.4 Silo Level Controls
2.30.15 Coal Crusher
2.30.16 Vibrating Feeders
2.30.17 Tripper
2.30.18 Trackmobile
2.30.19 En-Masse Chain Conveyors
2.31 ASH HANDLING SYSTEM
2.31.1 Boiler Room Ash Handling System
2.31.1.1 Ash Hopper
2.31.1.2 Clinker Grinder
2.31.1.3 Conveyor Piping
2.31.1.4 Vacuum and Combination Vacuum/Pressure Systems
2.31.1.4.1 Vacuum System
2.31.1.4.2 Combination Vacuum/Pressure Systems
2.31.1.4.3 Pump Unit
2.31.1.4.4 Control Cabinet
2.31.1.4.5 Controls
2.31.1.4.6 Automatic Air Valve
2.31.1.5 Ash Silo
2.31.1.6 Conveyor Type Ash Handling System
2.31.1.6.1 Drag Chain Conveyor
2.31.1.6.2 Casing
2.31.2 Ash Handling Controls
2.31.3 Submerged Drag Chain Conveyor (SDCC)
2.31.4 Dense Phase Ash Handling
2.31.5 Fly Ash Collectors

PART 3 EXECUTION

3.1 EXAMINATION
3.2 EARTHWORK
3.3 EQUIPMENT ERECTION
3.4 STORAGE TANK INSTALLATION
3.5 PIPING INSTALLATION
3.5.1 Pipe Sleeves
3.5.1.1 Pipes Passing Through Waterproofing Membranes
3.5.1.2 Optional Counterflashing
3.5.2 Pipe Joints
3.5.2.1 Threaded Joints
3.5.2.2 Welded Joints
3.5.2.2.1 Beveling
3.5.2.2.2 Alignment
3.5.2.2.3 Erection
3.5.2.2.4 Defective Welding
3.5.2.2.5 Electrodes
3.5.2.3 Flanges and Unions
3.5.3 Supports
3.5.3.1 General
3.5.3.2 Seismic Requirements
3.5.3.3 Structural Attachments

3.5.4 Anchors
3.5.5 Pipe Expansion
3.5.5.1 Expansion Loops
3.5.5.2 Expansion Joints
3.5.6 Valves
3.6 BURIED PIPING INSTALLATION
3.6.1 Protective Coating for Underground Steel Pipe
3.6.2 Cleaning of Surfaces to be Coated
3.6.3 Coating Materials
3.6.3.1 Bituminous Pipe Coating
3.6.3.2 Polyethylene Pipe Coating
3.6.3.3 Tape-Wrap Pipe Coating
3.6.3.4 Epoxy Coating System
3.6.3.5 Coating Inspection and Testing
3.6.4 Installing Buried Piping
3.6.5 Fiberglass Reinforced Plastic (FRP) Pipe
3.6.5.1 Installation
3.6.5.2 Thrust Blocks
3.6.5.3 Curing of Field-Bonded Joints
3.6.5.4 Metal to FRP Connections
3.6.6 Buried Fuel Piping
3.7 CATHODIC PROTECTION
3.8 FIELD PAINTING
3.9 CLEANING OF BOILERS AND PIPING FOR TESTING
3.9.1 Boiler Cleaning
3.9.2 Boiler Water Conditioning
3.10 MANUFACTURERS' FIELD SERVICES
3.11 FIELD TRAINING
3.12 FRAMED INSTRUCTIONS
3.13 TESTS
3.13.1 Hydrostatic Tests
3.13.2 Efficiency and Operating Tests
3.13.3 Test of Fuel Burning Equipment
3.13.4 Test of Deaerating Feedwater Heater
3.13.5 Test of Water Treatment Equipment
3.13.6 Test for Steam Purity and Water Level Stability
3.13.6.1 Conductivity Tests for Boilers without Superheaters
3.13.6.2 Conductivity Test, Boilers with or without Superheaters
3.13.6.3 Water Level Stability Test

-- End of Section Table of Contents --

Preparing Activity: USACE

Superseding without Revision
UFGS-23 70 01.00 10 (January 2008)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023

SECTION 23 52 30.01 10

CENTRAL COAL-FIRED STEAM-GENERATING SYSTEM
05/20

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

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

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

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

PART 1 GENERAL

1.1 REFERENCES

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

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

to update the issue dates.

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

****

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

ACOUSTICAL SOCIETY OF AMERICA (ASA)

ASA S1.13	(2005; R 2010) Methods for the Measurement of Sound Pressure Levels in Air (ASA 118)

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

AMCA 801	(2001; R 2008) Industrial Process/Power Generation Fans: Specification Guidelines

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)

ABMA 9	(2015) Load Ratings and Fatigue Life for Ball Bearings
ABMA 11	(2014) Load Ratings and Fatigue Life for Roller Bearings

AMERICAN BOILER MANUFACTURERS ASSOCIATION (ABMA/BOIL)

ABMA Boiler 203	(2002) A Guide to Clean and Efficient Operation of Coal-Stoker-Fired Boilers
ABMA Boiler 402	(2012) Boiler Water Quality Requirements and Associated Steam Quality for Industrial/Commercial and Institutional Boilers

AMERICAN GAS ASSOCIATION (AGA)

AGA XR0603	(2006; 8th Ed) AGA Plastic Pipe Manual for Gas Service

AMERICAN GEAR MANUFACTURERS ASSOCIATION (AGMA)

AGMA 6013	(2006A; R2016) Standard for Industrial Enclosed Gear Drives
ANSI/AGMA 6113	(2016B) Standard for Industrial Enclosed Gear Drives (Metric Edition)

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z83.19/CSA 2.35	(2017; R 2022) Gas-Fired High-Intensity Infrared Heaters

AMERICAN PETROLEUM INSTITUTE (API)

API STD 610	(2010; Errata 2011) Centrifugal Pumps for Petroleum, Petrochemical, and Natural Gas Industries
API Spec 15LR	(2001; R 2018) Specification for Low Pressure Fiberglass Line Pipe

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

AREMA Eng Man	(2017) Manual for Railway Engineering

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.20.1	(2013; R 2018) Pipe Threads, General Purpose (Inch)
ASME B1.20.2M	(2006; R 2011) Pipe Threads, 60 Deg. General Purpose (Metric)
ASME B16.3	(2021) Malleable Iron Threaded Fittings, Classes 150 and 300
ASME B16.4	(2021) Gray Iron Threaded Fittings; Classes 125 and 250
ASME B16.5	(2020) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard
ASME B16.9	(2018) Factory-Made Wrought Buttwelding Fittings
ASME B16.11	(2022) Forged Fittings, Socket-Welding and Threaded
ASME B16.15	(2018) Cast Copper Alloy Threaded Fittings Classes 125 and 250
ASME B16.18	(2021) Cast Copper Alloy Solder Joint Pressure Fittings
ASME B16.21	(2021) Nonmetallic Flat Gaskets for Pipe Flanges
ASME B16.26	(2018) Standard for Cast Copper Alloy Fittings for Flared Copper Tubes
ASME B16.34	(2021) Valves - Flanged, Threaded and Welding End
ASME B16.39	(2020) Standard for Malleable Iron Threaded Pipe Unions; Classes 150, 250, and 300
ASME B31.1	(2022) Power Piping
ASME BPVC SEC I	(2017) BPVC Section I-Rules for

	Construction of Power Boilers
ASME BPVC SEC IX	(2017; Errata 2018) BPVC Section IX-Welding, Brazing and Fusing Qualifications
ASME BPVC SEC VIII D1	(2019) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1
ASME CSD-1	(2021) Control and Safety Devices for Automatically Fired Boilers
ASME PTC 4	(2013) Fired Steam Generators
ASME PTC 10	(1997; R 2014) Performance Test Code on Compressors and Exhausters
ASME PTC 19.11	(2008; R 2013) Steam and Water Sampling, Conditioning, and Analysis in the Power Cycle

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C203	(2020) Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot-Applied
AWWA C213	(2022) Fusion-Bonded Epoxy Coatings and Linings for Steel Water Pipe and Fittings
AWWA C700	(2020) Cold-Water Meters - Displacement Type, Metal Alloy Main Case

ASTM INTERNATIONAL (ASTM)

ASTM A36/A36M	(2019) Standard Specification for Carbon Structural Steel
ASTM A53/A53M	(2022) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A106/A106M	(2019a) Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
ASTM A167	(2011) Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A179/A179M	(1990; R 2012) Standard Specification for Seamless Cold-Drawn Low-Carbon Steel Heat-Exchanger and Condenser Tubes
ASTM A242/A242M	(2013; R 2018) Standard Specification for High-Strength Low-Alloy Structural Steel
ASTM A249/A249M	(2018a; R 2023) Standard Specification for

	Welded Austenitic Steel Boiler, Superheater, Heat-Exchanger, and Condenser Tubes
ASTM A285/A285M	(2017) Standard Specification for Pressure Vessel Plates, Carbon Steel, Low- and Intermediate-Tensile Strength
ASTM A350/A350M	(2023) Standard Specification for Carbon and Low-Alloy Steel Forgings, Requiring Notch Toughness Testing for Piping Components
ASTM A514/A514M	(2022) Standard Specification for High-Yield-Strength, Quenched and Tempered Alloy Steel Plate, Suitable for Welding
ASTM A516/A516M	(2017) Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service
ASTM A568/A568M	(2019a) Standard Specification for Steel, Sheet, Carbon, Structural, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for
ASTM A653/A653M	(2023) Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A659/A659M	(2012; R 2017) Standard Specification for Commercial Steel (CS), Sheet and Strip, Carbon (0.16 Maximum to 0.25 Maximum Percent), Hot-Rolled
ASTM A688/A688M	(2018; R 2022) Standard Specification for Welded Austenitic Stainless Steel Feedwater Heater Tubes
ASTM A733	(2016; R 2022) Standard Specification for Welded and Seamless Carbon Steel and Austenitic Stainless Steel Pipe Nipples
ASTM B42	(2020) Standard Specification for Seamless Copper Pipe, Standard Sizes
ASTM B68/B68M	(2011) Standard Specification for Seamless Copper Tube, Bright Annealed (Metric)
ASTM B88	(2022) Standard Specification for Seamless Copper Water Tube
ASTM B88M	(2020) Standard Specification for Seamless Copper Water Tube (Metric)
ASTM B111/B111M	(2018) Standard Specification for Copper and Copper-Alloy Seamless Condenser Tubes and Ferrule Stock

ASTM C27	(1998; R 2022) Fireclay and High-Alumina Refractory Brick
ASTM C62	(2017) Standard Specification for Building Brick (Solid Masonry Units Made from Clay or Shale)
ASTM C155	(1997; R 2022) Standard Specification for Insulating Firebrick
ASTM C401	(2012; R 2022) Alumina and Alumina-Silicate Castable Refractories
ASTM D888	(2012; E 2013) Dissolved Oxygen in Water
ASTM D1066	(2018; E 2018) Standard Practice for Sampling Steam
ASTM F1139	(1988; R 2019) Steam Traps and Drains
ASTM G21	(2015; R 2021; E 2021) Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi

COMPRESSED AIR AND GAS INSTITUTE (CAGI)

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

CONVEYOR EQUIPMENT MANUFACTURERS ASSOCIATION (CEMA)

CEMA B105.1	(2015) Welded Steel Conveyor Pulleys
CEMA Belt Book	(2014; Errata 2016; Tech Statement 1 2016) Belt Conveyors for Bulk Materials

EXPANSION JOINT MANUFACTURERS ASSOCIATION (EJMA)

EJMA Stds	(2015) (10th Ed) EJMA Standards

HEAT EXCHANGE INSTITUTE (HEI)

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

HYDRONICS INSTITUTE DIVISION OF AHRI (HYI)

HYI-005	(2008) I=B=R Ratings for Boilers, Baseboard Radiation and Finned Tube (Commercial)

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C37.90	(2005; R 2011) Standard for Relays and Relay Systems Associated With Electric

Power Apparatus

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

MSS SP-58	(2018) Pipe Hangers and Supports - Materials, Design and Manufacture, Selection, Application, and Installation
MSS SP-70	(2011) Gray Iron Gate Valves, Flanged and Threaded Ends
MSS SP-71	(2018) Gray Iron Swing Check Valves, Flanged and Threaded Ends
MSS SP-80	(2019) Bronze Gate, Globe, Angle and Check Valves
MSS SP-85	(2011) Gray Iron Globe & Angle Valves Flanged and Threaded Ends

NACE INTERNATIONAL (NACE)

NACE SP0185	(2007) Extruded Polyolefin Resin Coating Systems with Soft Adhesives for Underground or Submerged Pipe

NATIONAL BOARD OF BOILER AND PRESSURE VESSEL INSPECTORS (NBBI)

NBBI NB-23 PART 1	(2013) National Board Inspection Code - Part 1 Installation

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA ICS 1	(2022) Standard for Industrial Control and Systems: General Requirements
NEMA MG 1	(2021) Motors and Generators
NEMA SM 23	(1991; R 2002) Steam Turbines for Mechanical Drive Service

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70	(2023) National Electrical Code
NFPA 85	(2023) Boiler and Combustion Systems Hazards Code
NFPA 329	(2015) Recommended Practice for Handling Releases of Flammable and Combustible Liquids and Gases

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

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

RUBBER MANUFACTURERS ASSOCIATION (RMA)

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

SOCIETY FOR PROTECTIVE COATINGS (SSPC)

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

U.S. DEPARTMENT OF DEFENSE (DOD)

UFC 3-301-01	(2023) Structural Engineering

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

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

UNDERWRITERS LABORATORIES (UL)

UL 296	(2017; Reprint Nov 2022) UL Standard for Safety Oil Burners
UL 726	(1995; Reprint Oct 2013) Oil-Fired Boiler Assemblies
UL 795	(2016; Reprint May 2022) UL Standard for Safety Commercial-Industrial Gas Heating Equipment

1.2 SUBMITTALS

****

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

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

Air Force, and NASA projects.

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

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

****

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

SD-02 Shop Drawings

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

Equipment Erection; G[, [_____]]

SD-03 Product Data

Steam-Generating Units

Spare Parts

Framed Instructions

Welding

SD-06 Test Reports

Tests

SD-10 Operation and Maintenance Data

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

1.3 QUALITY ASSURANCE

1.3.1 Welding

****

NOTE: Where pipeline, structural, or other welding is required on the same project, tests will be required accordingly. Testing may be by the coupon method as prescribed in the welding code or by special radiographic methods. If the need exists for more stringent requirements for weldments, delete the first bracketed statement and delete the welding submittal.

****

[Submit a copy of qualified procedures and a list of names and identification symbols of qualified welders and welding operators, and a proposed performance test procedure, 30 days prior to the proposed test date, containing a complete description of the proposed test along with calibration curves or test results furnished by an independent testing laboratory of each instrument, meter, gauge, and thermometer to be used in the tests. No test will commence until the procedure has been approved. Submit complete plan for water treatment, including proposed chemicals to be used and nationally recognized testing codes applicable to the system, prior to system startup. Weld piping in accordance with qualified procedures using performance qualified welders and welding operators. Procedures and welders are to 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. Notify the Contracting Officer 24 hours in advance of tests and perform the tests at the work site if practicable. The welder or welding operator must apply his assigned symbol near each weld he makes as a permanent record.] [Weld structural members in accordance with Section 05 05 23.16 STRUCTURAL WELDING. Welding and nondestructive testing procedures are specified in Section 40 05 13.96 WELDING, PRESSURE PIPING.]

1.3.2 Use of Asbestos Products

****

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

****

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

1.4 DELIVERY, STORAGE, AND HANDLING

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

1.5 EXTRA MATERIALS

Submit spare parts data for each item of equipment specified, after approval of the detail drawings and not later than [_____] months before the date of beneficial occupancy. Include in the data a complete list of

spare parts and supplies, with current unit prices and source of supply, and a list of the parts recommended by the manufacturer to be replaced after [1] and [3] years of service.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

2.1.1 Standard Products

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

2.1.2 Nameplates

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

2.1.3 Prevention of Rust

Unless otherwise specified, surfaces of ferrous metal subject to corrosion will 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 will be prime and finish painted with the manufacturer's standard heat resistant paint to a minimum thickness of 0.025 mm 1 mil.

2.1.4 Equipment Guards and Access

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

2.2 BOILERS

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

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

Rated capacity	[_____] kg/hour pounds/hour
Steam outlet temperature	[_____] degrees C degrees F
Site elevation	[_____] m feet
Ambient air temperatures	[_____] to [_____] degrees C degrees F
Reference air temperature	27 degrees C 80 degrees F

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

2.2.1 Capacity

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

2.2.2 Electrical Equipment

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

2.2.2.1 Motor Ratings

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

2.2.2.2 Motor Starters

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

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

not shown on the electrical drawings must be provided. Where two-speed or variable-speed motors are indicated, solid-state variable-speed controllers may be provided to accomplish the same function.

2.2.3 Boiler Design Requirements

2.2.3.1 Radiant Heating

****

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

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

****

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

2.2.3.2 Heat Input

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

2.2.3.3 Combustion Gas

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

2.2.3.4 Ash Discharge

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

2.2.3.5 Radiant Heating Surface

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

2.2.3.6 Furnace Volume

Furnace volume for watertube or firetube boilers is defined as the cubical volume between the top of the grate and the first plane of entry into, or between, the tubes. If screen tubes are utilized, they constitute the plane of entry.

2.2.3.7 Boiler Operating Capacity

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

2.2.3.8 Boiler Output Capacity

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

2.2.3.9 Boiler Markings

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

Each boiler must be stamped with:

a. Maximum continuous capacity in Watts Btuh.

b. Radiant heating surface in square meters feet.

c. Total heating surface in square meters feet.

d. Furnace volume in cubic meters feet.

e. Boiler unit design maximum allowable working pressure.

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

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

2.3 BOILER DETAILS

2.3.1 Packaged Steam-Generating Units

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

Submit [6] [_____] complete copies of operating instructions, prior to the training course, outlining the step-by-step procedures required for system startup, operation, and shutdown. Include in the instructions the manufacturer's name, model number, service manual, parts list, and brief description of all equipment and their basic operating features. Submit

[6] [_____] complete copies of maintenance instructions, prior to the training course listing routine maintenance procedures, possible breakdowns and repairs, and troubleshooting guides. The instructions will include piping layout, equipment layout, and simplified wiring, and control diagrams of the system as installed.

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

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

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

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

2.3.2 Watertube Boilers

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

2.3.2.1 Drums

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

2.3.2.2 Tubes

Tubes will be no less than 50 mm 2 inches in diameter, electric welded or seamless steel, and be connected to the drums and headers by expanding into bored tube seats. Boilers will have water-cooled furnace walls of a design suitable for the application. Lower header of sidewalls will be round design with tubes welded to header stubs. Each waterwall header must have enough supply and riser tubes to ensure that no portion of the waterwalls will become water starved at maximum capacity.

2.3.2.3 Baffles

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

2.3.2.4 Access Doors

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

2.3.2.5 Miscellaneous Pipe Connections

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

2.3.2.6 Superheater Design

****

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

****

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

piping. Extend the superheater terminals to sufficiently clear the boiler walls to facilitate connecting thereto. Any superheater piping must be extended beyond the boiler front wall line, 900 mm 3 feet beyond casing. Minimize header penetrations through the casing. Provide adequate superheater piping to mount the safety valves. The design must minimize external corrosion on the superheater and reheater due to molten slag or fouling. Minimize the location of headers in the gas stream. Spray desuperheaters must be complete with thermal sleeves of sufficient length to prevent droplets of water from coming in contact with the hot wall of the pipe. Arrange the sleeves so they attach securely to the pipe, but in a manner that will permit differential expansion.

2.3.2.7 Boilers and Firing Equipment

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

2.3.3 Boiler Settings

2.3.3.1 Boiler Material

Conform materials to the following:

2.3.3.1.1 Firebrick

ASTM C27, class as recommended by the boiler manufacturer.

2.3.3.1.2 Insulating Brick

ASTM C155

2.3.3.1.3 Castable Refractory

ASTM C401. The minimum modulus of rupture for transverse strength will be no less than 4.1 MPa 600 psi after being heat-soaked for 5 hours or more at a temperature in excess of 1371 degrees C 2,500 degrees F.

2.3.3.1.4 Mortar, Air-Setting, Refractory

As recommended by the boiler manufacturer.

2.3.3.1.5 Brick, Common

ASTM C62

2.3.3.1.6 Galvanized Steel Sheets

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

2.3.3.1.7 Uncoated Steel Sheets and Strips, Low Carbon

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

2.3.3.2 Firebox, Packaged Type

Install boiler refractories and insulation to permit free expansion

without placing undue stress on the boiler or refractory. Insulation and jacket must provide a casing temperature not exceeding 77 degrees C 170 degrees F in an ambient temperature of 38 degrees C 100 degrees F with a surface wind velocity not exceeding 254.0 mm/second 50 fpm while operating at full load.

2.3.3.3 Watertube, Waterwall Type

****

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

****

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

****

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

cost savings due to reduced boiler radiation losses.
****

2.3.3.3.1 Boiler Roof

Boiler roof will have a casing constructed no thinner than 3.416 mm 10 gauge black steel sheet. Refractory lining will consist of 63.5 mm 2-1/2 inches, minimum, of high-duty refractory backup behind the roof tubes and sufficient thickness of high temperature block insulation or mineral wool blanket to limit the maximum casing temperature in the furnace area to [54] [_____] degrees C [130] [_____] degrees F with a surface air velocity of 508.0 mm/second 100 fpm and an ambient air-temperature of 27 degrees C 80 degrees F when operating at full capacity. Exposed portions of the boiler drums must be insulated with 75 mm 3 inches of suitable mineral wool blanket or block insulation. Manholes and other inspection and access openings, identification plates, and stamps will have insulation finished neatly against a metal ring provided for this purpose.

2.3.3.3.2 Bridge Walls

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

2.3.3.3.3 Settling Chamber

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

2.3.3.3.4 Expansion Joints

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

2.3.3.3.5 Firebrick

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

2.3.3.3.6 Plastic Refractory

Install plastic refractory in accordance with the manufacturer's

recommendations and by workmen skilled in its application.

2.3.3.4 Watertube, Waterwall (Packaged Type) Unit

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

2.3.4 Boiler Fittings and Appurtenances

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

2.3.4.1 Water column

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

2.3.4.2 Water Gauge

Provide water gauge drain valve of the straight-through type.

2.3.4.3 Low Water Cutoff

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

2.3.4.4 Bypass Button

Provide a spring-loaded shunt bypass button to prevent nuisance shutdowns during sightglass blowdown.

2.3.4.5 Steam Gauge

Provide steam gauge for each boiler in a visible location on the boiler.

2.3.4.6 Feed and Check Valves

Provide feed and check valves adjacent to each boiler feed nozzle.

2.3.4.7 Continuous Blowdown Valve

****

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

****

Continuous blowdown valve must be manual proportioning type fabricated of

corrosion-resistant steel. Equip the valve with a micrometer dial and pointer to indicate the proportional setting.

2.3.4.8 Safety Valves

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

2.3.4.9 Blowoff Valves

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

2.3.4.10 Steam Nonreturn Valve

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

2.3.4.11 Feedwater Regulator

Connect feedwater regulator, sized for the application, complete with all necessary piping and accessories for automatic operation. Provide valved bypass around control valve. [Provide units with device to lock regulator in existing position in case of power failure.] [Provide units with manual/automatic selector panel located on instrument panel.] Provide feedwater control element with a drain valve. Fit the feedwater line with a thermometer well.

2.3.4.12 Soot Blowers

****

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

****

Furnish soot blowers as required to effectively clean all tube surfaces within the boiler. Use adjustable steam blowing pressure. Construct elements within the boiler of heat-resisting alloys suitable for the flue gas temperature encountered and are removable without disturbing the boiler tubes. Furnish soot blowers complete with necessary auxiliaries and connect in accordance with the manufacturer's recommendations. Provide soot blowers that are [permanently-mounted, rotary type manually-operated by a single chain. Provide quick-opening, positive-closing type valve located in the blower head, external to the boiler, with the working parts protected from the furnace gases, and operate by the same chain that rotates the element. Provide continuous

chains that extend within easy reach of the operating floors. Furnish blowers complete with necessary auxiliaries and connect in accordance with the manufacturer's recommendations.] [electrically-operated rotary or retractable type, except that soot blowers exposed to flue gas temperatures over 815 degrees C 1,500 degrees F must be retractable type only. Provide rotary type soot blowers with a quick-opening, positive closing type valve located in the blower head, external to the boiler, with the working parts protected from the furnace gases, and operate valve by the same motor that rotates the element. Provide electrically-operated retractable type soot blowers with either single motor-driven, totally-enclosed drive carriage with dual rack-and-pinion drives or dual-motor electric drive enclosed in a protective steel housing. Include starters and pushbutton stations for electrically-operated soot blowers.]

2.4 STOKER EQUIPMENT

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

Proximate Analysis	Percent, Dry
Moisture	[_____]
Volatile Matter	[_____]
Fixed Carbon	[_____]
Ash	[_____]
Ultimate Analysis	Percent, Dry
Carbon	[_____]
Hydrogen	[_____]
Nitrogen (Calc)	[_____]
Sulfer	[_____]
Chlorine	[_____]
Ash	[_____]
Oxygen (Diff)	[_____]
Btu/lb as received	[_____]
Btu/lb - dry	[_____]
Grindability	[_____]

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

2.4.1 Spreader Stokers

****

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

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

Underfeed or pulsating grate stokers may be specified for firebox packaged boilers when bituminous coal of any composition is used. Underfeed stokers will be the screw-feed type for boilers with capacity of less than 1635 kg (3600 pounds) of steam per hour, and the ram type for larger boilers. Pulsating grate units will be

water-cooled and complete with automatic coal feed and continuous ash removal. Conveyor stokers may be specified for watertube boilers if suitable for the type of coal available. Chain or traveling grate may be specified by deletion of the inapplicable type of grate, or the choice between the two types may be left to the Contractor by including both types in the description. If steam drives are specified, plant must have an auxiliary boiler or an alternate source of steam for startup. The following is a general guide in determining which type of grates to investigate:

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

****

Provide overfeed self-feeding typespreader stokers suitable for burning a portion of the coal in suspension, but sized assuming 100 percent combustion on the grate. [Distribute coal evenly across the full width of the grate by no less than [_____] feeder units. Design unit for operation of any feeder independently of the others, or make it possible to operate all feeders simultaneously.] Provide mechanical-rotating type feeders that are capable of handling and uniformly distributing coal over the grate area and have no moving parts within the combustion chamber. Where moving parts are exposed to excessive heat, protect all bearings by suitable water jackets. Provide grease or oil lubrication for all bearings. Design stoker for readily adjustable feed distribution of coal on the grates.

2.4.1.1 Spreader Stoker Grates

****

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

****

Ensure grates for spreader stoker firing are the high air-resistant type especially designed and arranged for powered mechanical or compressed air actuated dumping in sections. Ensure openings provide proper distribution of air under the fuel bed. [Provide grates 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.] Provide heavy-duty, heat-resisting cast-iron grates. Perform mechanical dumping with [steam-] [air-] [water-]actuated power cylinders

connected to the grates, and furnish grates complete with cylinders, linkages, valves, and piping as required. Ensure each section dumps independently of other sections. Provide necessary over-fire air jets complete with fans, ducts, and air control valves as required for proper turbulence and combustion. Ensure grate drives are independent of feeder drives to provide independent speed variation of feeders and grates.

2.4.1.2 Traveling Grates

Provide high air-resistant type traveling grates especially designed for spreader stoker firing and for continuous ash discharge. Ensure openings provide proper distribution of air under the fuel bed. Provide heavy-duty, heat-resisting cast-iron grates, and ensure individual sections are replaceable without taking the grate out of service. Place air seals around grate to hold air leakage to a minimum. Furnish moving grates complete with supporting steel, shafts, sprockets, chain, gears, skid bars, and bearings as required. Enclose the front end of the grates where the ash is discharged with a dust-tight enclosure made of heavy cast-iron plates no less than 15.9 mm 5/8 inch thick and properly protect with firebrick where exposed to the furnace, or use a refractory-lined steel plate. Fit the vertical fronts of the enclosure with refractory-lined inspection and access doors, one for each feeder. Seal the roof of the enclosure with refractory to protect the metal parts from the furnace temperature. Enclose the underside of the grates to form a chamber. Construct hopper for receiving the ashes as indicated or as recommended by the manufacturer. Privude over-fire air jets as required for proper turbulence and combustion.

2.4.1.3 Vibrating Grate

Design high air-resistant type vibrating grate especially for spreader stoker firing and for continuous ash discharge. Provide grates that are either air- or water-cooled with openings to provide proper distribution of air under the fuel bed. Ensure grates are heavy-duty, heat-resisting cast iron and individual sections are replaceable. Provide a manual adjustment to regulate the ash bed thickness and automatically discharge ashes to the ash pit. Enclose the front of the grates where the ash is discharged with a dust-tight enclosure of heavy cast-iron plates no less than 15.9 mm 5/8 inch thick and properly protect with firebrick where exposed to the furnace, or use a refractory-lined steel plate. Fit the vertical fronts of this enclosure with refractory-lined inspection and access doors, one to each feeder. Seal roof of this enclosure with refractory for protecting the metal parts from the furnace temperature. Enclose the underside of the grates to form a chamber with a hopper for receiving the ashes. Provide over-fire air jets for turbulence and combustion.

2.4.1.4 Stoker Controls

Provide stoker controls toaccurately regulate the coal feed rate and that are the type required for connection to the combustion control system. Ensure 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, is possible without disconnecting linkage. Provide separate feeder and grate drives Drive grate through a variable speed transmission with devices for changing speed interlocked with fuel feed regulation. Adjust grate speed manually to allow synchronization with fuel feed. Run all gears and chains of the variable speed transmission and gear reduction units, as required, in a bath of oil and enclose in a

dust-tight and oil-tight case. Fit front and rear shafts of the grates with a forced lubrication system with fittings located outside the setting. Provide antifriction type bearings with hardened inner and outer races fitted with dust seals and easily accessible forced lubrication fittings. Provide stoker [and grate] with safety release devices to protect the mechanism from foreign materials or obstructions. Drive stoker by [electric motor] [steam turbine]. [Provide totally enclosed fan-cooled electric motor for installation in Class II, Division 1, Group F hazardous location in accordance with NFPA 70. Provide magnetic [across-the-line] [reduced voltage start] type motor starter with [general-purpose] [dust-tight] [explosion-proof] enclosure.] [Provide steam turbines utilized for stoker drives conforming to NEMA SM 23.]

2.4.1.5 Hoppers

Construct hoppers of steel plates no less than 6.4 mm 1/4 inch thick and with a capacity of no less than [_____] kg pounds per feeder. Provide hoppers with clean-out doors in the front of each feeder. Fit coal feed to the hoppers with concave type transitions to ensure the proper distribution of coal and coal fines across the width of the hoppers. Use stoker front plate to 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 connects to the boiler structural framing. Front must be cast-iron or steel plate refractory lined with [auxiliary firing doors and] clean-out doors of refractory lined cast-iron. Provide structural framing as required to support the stoker and its components from the boiler foundation or boiler room floor. Divide the area under the grates into no less than four airtight zones for supply of forced draft having zone control dampers with external indicating operating and locking devices. Ensure all pressure parts for water-cooled grates including watertubes, headers, and valves furnished by the stoker manufacturer are for boiler pressure specified and constructed in conformance with ASME BPVC SEC I.

2.4.1.6 Over-Fire Turbulence and Cinder and Dust Reinjection System

Provide spreader stokers with over-fire turbulence and cinder-and-dust reinjection systems. Either air or steam may be used as the transport medium. Provide air systems with operating air by a single, low volume, high-pressure fan, driven by a splashproof electric motor. Design, locate, and size reinjection system ejectors for maximum fly ash pickup from all points. Equip nozzles for each system with manometer connections and heavy-duty adjustable dampers fitted with locking devices and position indicators. Ensure nozzles provide maximum combustion efficiency and furnace turbulence. Provide a manometer connection and a permanent manometer immediately downstream from the main reinjection air supply damper. Provide a portable manometer.

2.4.2 Underfeed Stokers

****

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

****

2.4.2.1 Single Retort, Heavy-Duty Ram-Type Stokers

Equip single retort, heavy-duty ram-type stokers with stationary or moving grates and side dump plates, and provide with [steam] [electric motor]

drive and all necessary auxiliary equipment. Provide compressed air actuated dumping power cylinders. Feed coal from the hopper into the retort by means of a ram and distribute evenly 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. Provide dampers between ash pits and main air chamber under stoker to permit control of air distribution to the grate surface. Arrange dampers for operation from the front plate of the boiler. Air distribution must be such that the air pressure is greatest where the fuel bed is the thickest. Air quantity must vary in direct proportion with coal feed rate and controlled automatically.

2.4.2.1.1 Grate Surface

Include the underfeed retort area, air admitting tuyeres, side combustion grates, and the side dumping plates. Provide retorts consisting of 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. Ensure stokers having total grate width of more than 2.1 m 7 feet have movable grates providing positive lateral feeding of the coal from the retort toward the dump plates. Construct retort and grate sections of heavy-duty, heat-resisting cast iron, core for proper air distribution, and design for easy replacement of individual sections. Provide ash dump plates with necessary levers and linkage for hand operation from the front of the boiler.

2.4.2.1.2 Ram Feed

Provide mechanical [steam] [pneumatic or hydraulic] [driven by an electric motor connected through an efficient gear reduction unit, crankshaft, and connecting rod] ram feed. [Provide totally enclosed fan-cooled type motors [for installation in a Class II, Division 1, Group F hazardous location in accordance with NFPA 70]]. [Provide magnetic [across-the-line] [reduced voltage start] type motor starter with [general-purpose] [dust-tight] [explosion-proof] enclosure.] Provide stoker controls for connection to the combustion control system to accurately regulate the coal feed rate. Ensure manual setting of the coal feed rate is 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. Regulate the coal feed rate by varying the time increments between strokes of the ram. Protect the coal feeding mechanism from injury in case foreign materials obstruct normal operation using a throw-out release.

2.4.2.1.3 Hoppers

Construct hoppers of steel plates no less than 6.4 mm 1/4 inch thick and with a capacity of no less than [_____] kg pounds. Provide hoppers with clean-out doors. Use stoker front plate to 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 connects to the boiler structural framing. Provide cast-iron or steel plate, refractory lined front with [auxiliary firing doors and] clean-out doors of refractory lined cast-iron. Provide structural framing, as required, to support the stoker and its components from the boiler foundation or boiler room floor. Provide water spray pipes and nozzles for quenching the ashes in the ash pit.

2.4.2.2 Single Retort Screw Type Stokers

Equip single retort, heavy-duty, screw feed stokers with rectangular firepot, side dump grates, forced-draft fan, electric-motor drive, and all necessary auxiliary equipment. Feed coal from the hopper into the retort with a spiral worm conveyor designed to feed a constant amount of coal and to prevent coal from packing in the worm. [Provide dampers between ash pits and main air chamber under stoker to permit control of air distribution to the grate surface. Arrange dampers to operate manually from the front plate of the boiler.] Provide stoker with an integral, forced-draft fan driven by the stoker motor. Air quantity must vary in direct proportion with the coal feed rate and controlled automatically. Construct retorts and grates of heavy-duty, heat-resisting cast-iron, core for proper air distribution, and design for easy replacement of individual sections. Provide retorts of proper size and shape to distribute coal uniformly over the entire grate surface. Provide stationary grates on all sides of the retort as required to suit the firebox. [Provide ash dump grates on each side of the retort complete with necessary levers and linkages for hand operation from the front of the boiler.] Electric motor must be belt-connected to an efficient gear reduction unit which drives the feed screw and forced-draft fan. Immerse gear reduction unit in oil in a dustproof housing. Provide stoker controls that are suitable for connection to the combustion control system to accurately regulate the coal feed rate. Control feed rate to allow manual setting for no less than three speeds and neutral, in equal increments, with speed changes possible while stoker is running. Protect the coal feeding mechanism from injury in case foreign materials obstruct normal operation using a suitable release. Provide totally enclosed fan-cooled type motors [for installation in a Class II, Division 1, Group F hazardous location in accordance with NFPA 70]. Provide [manual] [[magnetic] [across-the-line] [reduced voltage start] type motor with [general-purpose] [dust-tight] [explosion-proof] enclosure.] Construct reinforced hoppers of 6.4 mm 1/4 inch steel sheet, minimum, and with a capacity of no less than [_____] kg pounds. Provide hoppers with suitable cleanout. Provide removable feed screw and conveyor compartment with cleanout. Do not rest stoker on boiler room floor.

2.4.3 Conveyor Stokers

****

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

****

Provide conveyor stokers that are the grate level feed, forced-draft [chain grate] [traveling grate] type with hoppers, feed gate, drive shaft, sprocket wheels, grate, [electric motor] [steam] drive, and all necessary auxiliary equipment. Feed coal automatically at a constant rate from the hopper onto the moving grate and distribute evenly across the full width of the grate. Provide stoker frame with no less than four air-tight zones for supply of forced draft and suitable zone control dampers with external indicating, operating, and locking devices.

2.4.3.1 Grates

Provide grates with individual sections constructed of heavy-duty, heat-resisting cast-iron, fit or core for proper air distribution, and design for easy replacement of individual sections. [Provide chain grates

with staggered links connected by pins to form a continuous flat chain the full width of the furnace.] [Provide traveling grateswith grate blocks mounted on carrier bars which, in turn, are fastened to two or more drive chains to form a continuous flat grate surface the full width of the furnace.] Support continuous grates at the ends by suitable sprockets and at intermediate points on suitable tracks or skids.

2.4.3.2 Grate Operation

****

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

****

Drive conveyor grate by [electric motor connected through a suitable speed reduction unit] [steam] [hydraulically operated variable speed drive]. Enclose gears and chains required for the drive in a dustproof and oil-tight housing. Ensure main shafts for the grates have a forced system of lubrication with fittings located outside the casing or have self lubricating bearings. If the forced lubrication system is supplied, fit bearings with dust seals and easily accessible forced lubrication fittings. Provide stoker controls that are suitable for connection to the combustion control system to accurately regulate the coal feed rate. Manually set the coal feed rate by varying stoker feed, as required to maintain any desired capacity between 25 to 125 percent of boiler capacity without disconnecting linkage. Change feed rate by varying the speed of the grate. Air volume must automatically vary in direct proportion with the feed rate. Vary possible feed rate in no less than 10 equal increments. [Provide totally enclosed fan-cooled type electric motor [for installation in a Class II, Division 1, Group F hazardous location in accordance with NFPA 70.]] [Provide [manual] [magnetic] [across-the-line] [reduced voltage start] type motor starter with [general-purpose] [dust-tight] [explosion-proof] enclosure.]

2.4.3.3 Hoppers

Construct hoppers of steel plates no less than 6.4 mm 1/4 inch thick, with a capacity of no less than [_____] kg pounds, and provide with suitable cleanout doors. Fit coal feed to the hoppers with concave type transitions to ensure the proper distribution of coal and coal fines across the width of the hoppers. Construct stoker frame of cast-iron, cast steel, or forgings, and properly cool or otherwise protect all parts of the stoker, except the grates, from the furnace heat to prevent damage by warping or undue expansion. Use furnace arrangement and shape as recommended by the stoker manufacturer to ensure proper combustion of the fuel. Stoker front plate must 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 connects to the boiler structural framing. Front must be cast-iron or steel plate, refractory lined with cleanout doors of refractory lined cast iron. Use structural framing, as required, to support the stoker and its components from the boiler foundation or boiler room floor. At the end of the grate, discharge the ash into a bunker or pit as indicated. Provide bunker with a dust-tight enclosure made of steel plates no less than 15.9 mm 5/8 inch thick, properly protected with firebrick where exposed to the furnace; that is fitted with cast-iron, refractory lined inspection and access doors; and with provisions for ash removal.

2.4.4 Vibrating Grate Stokers

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

Provide grate level feed, forced-draft type virbrating grate stokers with the vibrating action of the grate used to feed the coal from the hopper through the furnace and discharge the ashes into the ash pit. Ensure stokers are complete with hopper, feed gate, grate, drive mechanism, and all necessary auxiliary equipment. Feed coal automatically from the hopper onto the grate and distribute evenly across the full width of the grate. Provide a manual adjustment to regulate the fuel bed thickness. Discharge ashes automatically and continuously to the ash pit. Divide the area under the grates into no less than four airtight zones for forced draft supply containing suitable zone control dampers with external indicating, operating, and locking devices.

2.4.4.1 Grates

Provide grates that are either air cooled or water cooled with grate bars in intimate contact with the watertubes. Provide grates with individually replaceable sections of iron or steel suitable for the temperatures encountered. Ensure pressure parts, including watertubes, headers, and valves are suitable for boiler pressure specified and constructed in accordance with ASME BPVC SEC I. Properly design grate sections for even air distribution over the entire grate area.

2.4.4.2 Stoker Controls

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

2.4.4.3 Hoppers

Construct hoppers of steel plates no less than 6.4 mm 1/4 inch thick, with a capacity no less than [_____] kg pounds, and provide with a suitable method of cleanout. Ensure furnace arches are designed for the intended use and that proper combustion of the fuel is provided. Incline lower furnace sidewall headers in a waterwall boiler to accommodate the inclined grate arrangement. Use stoker front to 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 connects to the boiler structural

framing. Front must be cast-iron or steel plate refractory lined with cleanout and access doors of refractory lined cast-iron. Provide structural framing, as required, to support the stoker and its components from the boiler foundation or boiler room floor. At the end of the grate, dscharge the ash into a bunker or pit as indicated. Provide bunker with a dust-tight enclosure made of steel plates no less than 15.9 mm 5/8 inch thick properly protected with firebrick where exposed to the furnace and fitted with cast-iron, refractory lined inspection and access doors, and provisions for ash removal as indicated.

2.5 PULVERIZED COAL BOILERS

****

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

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

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

****

Where indicated, provide pulverized coal boilers. Design boiler and boiler accessories specifically to operate on the fuel specified. Ensure boilers are complete with coal feeders, crushers, dryers, burners, ignition system, air preheater, economizer, soot blowers, controls, and complete furnace ash handling facilities. Fly ash collection and pollution control equipment is specified in Section 44 10 00 AIR POLLUTION CONTROL. Provide [horizontal] [vertical] type boilers that are [top] [bottom] supported. Provide ash hoppers which are dry, refractory-lined type divided into compartments, each containing a hydraulically-operated clean-out door. Support the hopper from the boiler and use a dry seal to provide gastight connection. Furnish forced draft and induced draft fans

with the boiler.

2.5.1 Coal Pulverizers

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

2.5.2 Burners

Design pulverized coal burners specifically for the boiler provided. Include an ignition system designed for ignition of pulverized coal.

2.5.3 Furnace Ash System

****
NOTE: Detail of piping supported in trenches will appear on the drawings.
****

Ensure boiler is the dry bottom type, discharging ash to the hopper compartments. Handle pulverized coal boiler ash hydraulically rather than pneumatically. Provide facilities for pulverized coal boiler ash handling as indicated. Do not mix fly ash with furnace ash but economizer ash can be combined with furnace ash as indicated. Provide dual ash dewatering bins to allow recirculation of ash conveying water as indicated. Provide each bin with automatic controls and hydraulically operated gate for ash unloading to trucks or railroad cars. Mainain hopper in flooded condition and hydraulically operate sluice gates to allow for periodic removal of ash. Fit each ash hopper compartment with double-roll, electric motor driven clinker grinders fitted with manganese steel crusher rolls and teeth. Provide discharge from the grinders to an adaptor or to a sump for feed to the centrifugal pump. Provide centrifugal pump for each hopper compartment and incorporate special abrasive resistant metals and special seals for abrasive slurry handling. Ensure drives are totally enclosed electric motors as indicated. Make ash slurry conveying pipelines of abrasive resistant alloy metal with a Brinell hardness number of approximately 280. Ensure wall thickness is no less than 13 mm 1/2 inch and pipe lengths do not exceed 5.5 m 18 feet. Provide tangent end type fittings with a Brinell hardness number of approximately 400 and with removable wearbacks, where applicable, or the integral wearback type. Provide loading facilities for ash removal of dewatering bins as indicated.

2.5.4 Pulverizer Rejects

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

2.5.5 Control Systems

Provide pulverized coal plant control systems in accordance with NFPA 85 and interlock to provide for a completely automatic boiler operation. Coordinate automatic controls for coal feed, pulverizer operation, combustion, and ash disposal systems.

2.5.5.1 Coal Master Control System

Regulate the total coal feed from the coal [bunkers] [silos] to the pulverizers in response to changing demand. Provide a parallel metering combustion control system that limits the firing rate to the actual total air flow available. Arrange the cross limiting of air and fuel so the air leads the fuel on load increase and trails the fuel on a load decrease. Provide a gain changer to compensate the fuel system for the number of pulverizers in service. Depending on the requirements of the pulverizer, actuate the coal master control system by the coal feeder speed or by the coal/air mixture. Ensure the total fuel controller is a standard, proportional plus integral controller with a derivative or rate term on the master demand only. Multiply change in master demand by the derivative circuit to assist in overfiring on load increase and underfiring on a load decrease. Make provision for taking any one of the pulverizers for each boiler out of service with firing continuing at reduced rates for extended periods during maintenance or during low demand intervals. Provide alarms and interlocks of the fuel master control as required by the boiler but include, as a minimum, a unit trip to run the fuel master to zero and alarm contacts for "fuel master at maximum," "fuel master at minimum," "fuel greater than air," and "air demand limiting fuel."

2.5.5.2 Primary Air

Provide primary air fan or suction air fan control for each system with all required damper operating and sensing control devices. Ensure primary air system fans exhaust into a duct common with individual pulverizer primary air flow dampers in order to control the flow required by each pulverizer. Maintain common duct pressure at a given set point by modulating fan inlet dampers. Provide gain compensation to maintain system response with a different number of fans in operation. Provide biasing between fans.

2.5.5.3 Air Temperature Control

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

2.5.5.4 Flame Safety System

Provide a burner control/flame safety system with the boiler. Meet the requirements specified in NFPA 85 as a minimum. Provide an interface between the analog control system and the flame safety system or burner control system. As a minimum, position coal feeders and pulverizer air dampers to respond to "unit tripped" and "pulverizer tripped" signals. Incorporate a pulverized coal ignition system. Incorporate boiler shutdown as well as normal monitoring of startup sequencing and normal operation. Ensure each burner has a scanner for the lighting system as

well as a scanner for the main flame.

2.6 FLUIDIZED BED COMBUSTION BOILERS

****

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

****

Where indicated, provide fluidized bed combustion boilers. The Contractor may provide either bubbling bed (AFB) or circulating bed (CFB) boilers. Use fluidizing velocities ranging from 1.2 to 3.7 m/second 4 to 12 fps for AFB boilers and ranging from 4.3 to 9.1 m/second 14 to 30 fps for CFB boilers. Ensure each boiler is in compliance with sulfur dioxide, nitrogen oxides, particulate, carbon monoxide, and all other emission regulations, as specified. Control the bed temperature within the appropriate range, normally 815 to 900 degrees C 1500 to 1650 degrees F to enhance sulfur capture, inhibit the formation of nitrogen oxides, enhance combustion efficiency, and limit carbon monoxide formation. In AFBs, generally introduce all the air required for combustion through the nozzles in the distribution plate in order to reduce the potential of forming reducing conditions within the bed that could cause severe corrosion of in-bed surfaces. The use of over-fire air in applications where it is needed to complete the burnout of carbon monoxide and the combustion of fines in the freeboard requires the approval of the Contracting Officer who will be satisfied that reducing conditions will not exist. CFB boilers may introduce as much as 40 to 50 percent of the combustion air as secondary air in one or more stages at various locations above the distribution plate. Design the boiler and boiler accessories specifically to operate with the specified fuel and sorbent. Provide boilers complete with the required crushers, dryers, coal and sorbent handling systems, burners, ignitors, air preheater, economizer, soot blowers, boiler controls and instrumentation, furnace ash handling system, draft systems, and superheater, where required.

2.6.1 General

Furnish the design, materials, and construction of equipment conforming to the applicable requirements of ASME BPVC SEC I and NFPA 85. Furnish the Manufacturer's Data Report required by ASME BPVC SEC I certified by the Authorized Inspector located in the manufacturer's shop. Make full provision so that each component can expand and contract under the operating cycle of temperatures without damage to itself or to any adjoining component, and without the leakage of any contained fluid outwards, or of air either inwards or outwards. Design the unit to accommodate thermal movement without side effects such as tearing, buckling, distortion, or vibration. Design the unit to prevent destructive vibration during normal operation. Provide balanced draft type furnace. Design the ducts and equipment from the forced draft fan, including the fluidized bed plenums, for pressures in accordance with NFPA 85. Provide access and observation doors to permit access to compartments and the observation of critical portions of the furnace and fluid bed. Anchor door frames securely. Provide doors with a suitable durable gasket, a device which when closed will force the door to an air-or gas-tight seal, and an interior design which will minimize erosion or deterioration of the inner surface from exposure to the internal

conditions at that point. Ensure refractory is an integral part of the door. Use manufacturer's standard access doors that approaches in size 450 mm 18 inch wide by 400 mm 16 inch high. Provide all observation ports and lance doors with sealing and aspirating air facilities. Convection pass velocity greater than 15.2 m/second 50 fps is not permitted. Base the convection pass velocity on maximum guaranteed excess air at Maximum Continuous Rating (MCR) plus five percentage points (i.e., if excess air is 20 percent, base the convection pass velocity on 25 percent excess air). In CFB designs where convection surface exists in the high solids circulation passes, a velocity not greater than 4.6 m/second 15 fps is permitted between the tubes, based on 25 percent excess air. Design equipment such that the interior surfaces of all water-filled pressure parts and superheater sections are capable of being chemically cleaned. Furnish, as required, fill and drain connections. Ensure each header is drainable. Provide the secondary air and flue gas system resistance curves.

2.6.2 Furnace and Boiler

Provide water-tube welded-wall type boiler, having in-bed tube surface for AFB offerings with natural and/or forced circulation. Use seamless tubes and weld all connections. Identify tubes of the electric resistance welding process, where used, and ultrasonically test along their entire length. Provide permanent thermocouples, as required, run to a terminal box outside the boiler casing. As a minimum, these thermocouples indicate:

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

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

c. Air and gas temperatures.

d. Water and steam temperatures.

Fusion weld drums throughout and fit with manholes and hinged covers at both ends. Monitor the hydrostatic test temperature carefully, as indicated in paragraph "TESTS," to avoid brittle failure. Furnish boiler drains sufficient in size and number to completely drain the water from the entire unit in not more than 1 hour at 0 kPa psig pressure. Equip the drum with internals for steam separation.

2.6.3 Forced Circulation System

Provide boiler designs utilizing horizontal in-bed evaporating surfaces with a forced circulation system. Install number and capacity of the pumps such that with one pump out of service, the maximum rating of the boiler can be carried with complete safety. In addition, loss of all pumps, with the unit at MCR, must allow for a safe and orderly shutdown (without fans) without damage to the boiler. Ensure pumps are single stage, centrifugal, driven by constant speed motors. Provide pumps complete with all necessary accessories, including welded suction and discharge connections, lubrication system, casing drain valves in duplicate, and any necessary auxiliary pumps, heat exchangers, or other equipment. The pumps must withstand the boiler test pressure and all operating pressures and temperatures without distortion, binding, or other effects. Ensure casings withstand the forces and moments imposed upon them by the connecting piping without disturbing the alignment or successful operation of the pumping units. Ensure construction is such as to permit inspection of the rotating parts without dismantling the suction

and discharge piping. Operate pumps satisfactorily at all loads, either by themselves or in parallel with the other pumps furnished. Provide motor operated pump suction valves. Furnish bypasses with valves around the pump isolating valves to maintain operating temperature in the idle pumps and piping. Provide discharge valves with impactor handwheels and lugs for air motor drive. Provide orifices, with protecting strainers as required, to assure adequate circulation to all parts of the boiler circuits. All materials that may come in contact therewith must be suitable to withstand acid and caustic boiler cleaning solutions. Provide connecting lines with stop valves between the main distributing header and the economizer inlet header for use as a circulating line to the economizer when the boiler is acid cleaned.

2.6.4 In-Bed Tube Surface (AFB Designs)

Provide in-bed tube surface as required to achieve steam generation or superheat temperature as defined in the data sheets. Ensure in-bed tubes are completely clear of bed material when the fluid bed (at the bed weight specified by the manufacturer at boiler MCR) is slumped. Alternatively, the manufacturer must ensure that the tubes are protected from overheating due to contact with a slumped bed and/or maintenance problems due to moisture in a slumped bed.

2.6.5 Coal and Sorbent Feed Systems

Furnish all equipment required to provide a boiler feed system to convey coal and sorbent to the boiler injection inlets. Size all components of these systems to provide flow of fuel and sorbent based on MCR condition in the boiler and the design coal and sorbent specified. Design the system to minimize the segregation or generation of fines.

2.6.5.1 AFB Coal Feed System

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

oxides emission in compliance. These systems must feed over-bed or in-bed and may be gravity, pneumatic, or a combination. Provide under-bed coal feed systems with coal dryers unless approved.

2.6.5.2 CFB Coal Feed Systems

For CFB systems, provide feed systems capable of providing the appropriate coal feed over the load range. Include weigh belt feeders, rotary feeders, screw conveyors or air swept feeders, or gravity-feed metered by weigh belt. Do not use rotary type feeders as the primary pressure sealing device. The fluidizing velocity in systems ranges from 4.3 to 9.1 m/second 14 to 30 fps. Permit maintenance of full load with loss of a single feed point. Design screw conveyors to operate continuously. Provide sorbent feed for CFB systems capable of providing the required proportion of sorbent over the load range. These systems must consist of a sorbent metering device weigh belt feeder and be fed by gravity, pneumatic injection, or air swept feeder. The sorbent must be fed in-bed, under-bed, or over-bed, and separately from the fuel.

2.6.6 Fluidized Bed Combustion Area

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

2.6.7 Bed Material Letdown System

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

2.6.8 Burners and Fuel Piping

Provide burners and burner equipment suitable for continuous service. Ensure parts subject to severe wear or deterioration are replaceable with a minimum of dismantling. Mount all valves or controls outside the boiler front and air housing. Ensure burner design provides positive and uniform mixing of the air and fuel at all loads, and produces sufficient turbulence to preclude stratification. The burner design must permit the firing of No. 2 fuel oil. Provide air atomizing type in-duct/over-bed burners. Ensure burners and/or ignitors have an aggregate capacity capable of bringing a cold unit up to ignition temperature using either precalcined limestone or spent bed material in 4 hours for AFBs, and 8 to 12 hours for CFBs, depending upon refractory limitations. Furnish

equipment for remote positioning, if required, of each burner gun at either the fully retracted or fully inserted position. Provide air operated positioning equipment including limit switches to indicate the position of the gun and all necessary drives, linkages, and mechanisms; and that automatically purges the fuel from the guns before retracting.

2.6.9 Air Distribution System

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

2.6.10 Mechanical Collector and Solids Recycle System for AFB Boilers

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

2.7 IGNITION OIL SYSTEM

****

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

****

2.7.1 Ignition Oil Pumps

Furnish ignition oil pumps as duplex types assuring 100 percent standby.

Provide pumps complete with coupling, coupling guard, and electric motor shop-mounted and aligned on a common skid.

2.7.2 Burners

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

2.7.3 Aboveground Oil Storage Tanks

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

2.7.4 Underground Oil Storage Tanks

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

2.8 COMBUSTION CONTROL EQUIPMENT

****

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

****

Provide combustion control equipment as a system by a single manufacturer. Install an automatic combustion control system for each boiler in accordance with the manufacturer's recommendations. Locate the controllers on the boiler room panel specified in paragraph BOILER ROOM PANELS AND INSTRUMENTS. Operate equipment either pneumatically, electrically, or electronically. Provide pneumatic control systems conforming to CAGI B19.1. Install air filter regulator sets at each control valve and transmitter in the system. Provide dual type master air filter regulator set on the control panel where one side can be cleaned and repaired while the other is in operation. Protect exterior control air piping and devices from freezing by use of a regenerative desiccant dryer. Provide each system with a selector switch or other means of manual control of the firing rate when required. Use electrical control devices that are rated at 120 volts and connect as specified in Section 26 20 00 INTERIOR DISTRIBUTION SYSTEM. Wire operating and limit controls to interrupt the ungrounded circuit conductor. [Steam and energy generating equipment must include instrumentation and sufficient metering for accountability interface with a future Energy Monitoring and Control System (EMCS).]

2.8.1 Positioning Type

Provide positioning type combustion control equipment that is capable of maintaining boiler steam pressure within plus or minus 2 percent of the set pressure over the complete range of boiler operation. Maintain excess air within plus or minus 10 percent of the original control setting. The efficiency will be maintained without appreciable manual adjustment. Provide system that is capable of maintaining the specified pressure provided that the load does not exceed a 15 percent per minute change in capacity at any one time. Connect the master transmitter to the main steam header where the steam pressure is to be controlled. Ensure the signal transmitted from this point to the master controller is a function of steam pressure. On multiple boiler installations, provide a means to base load on individual boilers while on automatic, and control each boiler unit individually. Make provision on the control system for adding on other boilers to the system with only minor wiring or piping changes on the panel. Ensure the fuel-to-air ratio on this system is adjustable from one knob that indicates increase and decrease of air in proportion to fuel. Limit the range of this adjustment to prevent operation below safe combustion limits.

2.8.2 Metering Type Combustion Control Equipment

****
NOTE: This paragraph will be deleted if controls with oxygen compensation specified in paragraph COMBUSTION CONTROLS WITH OXYGEN TRIM are used.
****

2.8.2.1 Fuel-Flow, Air-Flow Type Combustion Control

****
NOTE: This paragraph will be used for spreader stokers.
****

[Provide fuel-flow, air-flow type combustion control equipment that is the proportioning and reset type, and position the fuel feed or air flow and then adjust one to the other by a ratio controller operating from air flow and fuel feed. Include fuel-flow measuring elements and air-flow measuring elements. Panel-mount separate fuel feed and air-flow controllers along with a fuel-to-air ratio controller. Set the air-flow index by a measuring element in the air stream. Systems controlling fuel and air by line shafting and mechanical connections will not be acceptable.]

2.8.2.2 Two Element (Steam Pressure, Steam Flow)

****
NOTE: If underfeed, traveling grate, or vibrating grate stokers are specified, use this paragraph.
****

[Provide two element (steam pressure, steam flow) combustion control equipment that is the proportioning and reset type, and control the fuel feed or air flow either in parallel or series. Include measuring elements for steam flow, fuel feed, and air flow. Panel-mount separate steam pressure, fuel flow, and air flow controllers along with a fuel-to-air ratio controller. Measure the actual steam flow an orifice or other flow

measuring device in the steam line. Set air-flow by a measuring element in the combustion air stream. Systems controlling fuel and air by line shafting and mechanical connections will not be acceptable.]

2.8.2.2.1 Master Pressure Transmitter

Provide a master pressure transmitter and connect to the main steam header at a point where the steam pressure is to be controlled. Using the master controller, which is located on the panel, load the various individual boiler controllers according to steam pressure changes. On multiple boiler installations, provide an operator station to base load or bias each individual boiler while keeping its fuel and air controllers on automatic. Mount this boiler master station on the control panel between the master controller and the remainder of the control system. Provide indicators to show the loading impulse from the master controller to the boiler master station and each boiler master station output.

2.8.2.2.2 [Fuel Feed] [Steam-Flow] Transmitter

Provide a [fuel feed] [steam-flow] transmitter for each boiler and feed a signal to a fuel feed controller. Load each fuel feed controller using the master controller for the rate of [fuel feed] [steam-flow] corresponding to the rating of the respective boiler. Operate the fuel device controlling the rate of fuel feed. Incorporate proportional plus reset control features.

2.8.2.2.3 Air-Flow Transmitter

Provide air-flow transmitter for each boiler. The air-flow controller must control from this signal or in such other manner as to maintain a predetermined ratio of air to fuel. Provide an indicator showing the amount of any manual adjustment to the air-to-fuel ratio. Provide controller with proportional plus reset modes of control.

2.8.2.2.4 Automatic Controller

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

2.8.2.2.5 Power Units

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

2.8.2.2.6 Furnace Draft Controller

Provide furnace draft controller of the modulating type with each boiler. Design the draft controller to maintain automatically within 2.5 Pa 0.01 inch water column the desired furnace draft for which it has been set manually. Fix the position of the boiler outlet damper through a power operator. Provide an indicator to show the amount of any manual adjustment that might be made. Equip the draft regulator with a manual-automatic switch.

[2.8.3 Combustion Controls with Oxygen Trim

Flue gas oxygen trim may be furnished with combustion controls specified. Provide an oxygen analyzer and oxygen controller. Provide oxygen controller of the proportional band and reset type which feeds its signal in a biasing fashion into the fuel-to-air ratio system. Ensure the oxygen setpoint is a function of boiler load with operator biasing capability. Limit the amount of oxygen controller trim prevent potentially hazardous conditions caused by equipment failure or misoperation.

]2.8.4 Boiler Limit Controls

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

b. Provide a high-pressure limit switch to shutdown the fuel when steam pressure exceeds the preset safe limit. This equipment is additional to the operating controls.

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

d. Provide safety interlocks required by the applicable NFPA standard.

2.8.5 Burner Control/Fuel Safety System

2.8.5.1 Design Requirements

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

2.8.5.1.1 Maintenance and Reliability Requirements

In general, accomplish maintenance on-line and without imposing any special restrictions on overall plant operation. Provide diagnostic routines, interchangeable electronic cards or boards, and clear written procedures. Incorporate reliability, both software and hardware, into the system design. Include redundancy, loop distribution, component specifications and testing, and quality control to assure the highest level of system reliability.

2.8.5.1.2 Adverse Electrical Conditions

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

2.8.5.2 System Design

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

2.8.5.3 System Functional Requirements

2.8.5.3.1 Operating Modes

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

(1) Purge

(2) Igniter control

(3) Pulverizer control

(4) Feeder control

2.8.5.3.2 Furnace Purge and Boiler Monitor

Iincorporate prelight off and post purges of the furnace to ensure that the boiler is free of any accumulation of combustibles. Indicate completion of the furnace purge to the operator, after which the operator will reset the master fuel trip relay. A furnace purge is required on any master fuel trip. Ensure boiler monitor prevents starting any fuel equipment if the furnace firing permissives are not met. Provide indications to the operator of the status and the progress of the furnace purge. Ensure permissive indications are extinguished when the MFT is reset.

2.8.5.3.3 Mill Start-Stop Sequences

Start and stop the mill in three steps (ignitor, pulverizer, feeder) following fixed sequences. Provide system capable of transferring between the startup and shutdown sequences at any time. Monitor each mill and should any unsafe conditions occur, trip that mill. Provide a mill first out indication to indicate the initiating cause of trip. Delete the first out indication only upon reset of the mill trip relay. Provide startup and shutdown sequence indications to allow the operator to follow the progress of the mill startup or shutdown sequences. These indications must show the next step to be performed, as well as the progress through the sequences.

2.8.5.3.4 Ignitor Control

An ignitor group consists of the ignitors associated with a pulverizer burner group. Control ignitors associated with a burner group from a separate electropneumatic ignitor control package. Provide sequential starting of ignitors between burner groups. Start and stop the ignitors associated with a burner group from the insert panel and local push buttons. Provide an ignitor fuel trip (IFT) first out indication to indicate the initiating cause of the IFT. Ensure this indication is extinguished only when the IFT relay is reset.

2.8.5.3.5 Fuel Safety Subsystem

The fuel safety subsystem comprises the MFT system, IFT system, and pulverizer mill trip (MT) systems. Provide a mill trip system for each mill. Ensure each fuel safety system provides the protection for its respective fuel and includes a dedicated hardwired relay which may be directly operated from the operator insert panel. Ensure the master fuel trip system provides overall boiler protection, also includes a dedicated hardwired relay, and directly trips all other fuel safety system relays. Design the system to deenergize to trip.

2.8.5.3.6 Flame Monitoring

Individual self-checking flame scanners are required for each burner. Use ignitor flame safety devices that discriminate individually from any flame

that may exist at other burner locations. Ensure burner flame is discriminated individually from the associated ignitor flame and any other flame that may exist in the furnace. Ensure ignitor and burner flame discrimination covers 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, include extended tube scanners. Individual flame detector output level indicators are required. Make provisions for cooling and cleaning, if required.

2.8.5.3.7 Enclosures

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

2.8.5.3.8 Local Termination Boxes

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

2.8.5.3.9 Interconnecting Cable Requirements

Interconnecting cables between the logic cabinet, insert panel, local burner junction boxes, and local mill junction boxes must be via prefabricated plug-in cables, including connectors. Also, furnish flame scanner cables.

2.8.5.3.10 Buffered Output Signals

Fully isolate output signals required for tripping, control, and monitoring from each other. Ensure isolation is such that an open or short circuit in the related equipment does not affect other control systems.

2.9 BOILER ROOM PANELS AND INSTRUMENTS

2.9.1 Instrument Control Panel

Size instrument and control panel to contain all controls, instruments, gauges, and meters. Provide free-standing panel with faceplate of no less than 4.8 mm 3/16 inch steel, properly reinforced, and finished with the manufacturer's standard finish coating. Mount units flush on the panel as far as practicable. Flush mount controls, instruments, and other equipment, each fitting neatly into a cutout, and completely covering the

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

2.9.2 Indicators

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

2.9.3 Recorders

Provide servo mechanism type or multiple pen type recorders. Provide [circular] [strip] chart type. Minimum chart width is 100 mm 4 inches. Accuracy must be plus or minus 0.5 percent. Provide a separate scale calibrated in engineering units for each scale. Chart drive must be 120 volts ac. Provide one year's supply of chart paper.

2.9.4 Panel Display

****

NOTE: Steam flow meters will be specified for boilers having a continuous steam capacity of 4,540 kg 10,000 pounds or more per hour and must be integrating type where indicated. Feedwater meter will be provided on individual boilers not having steam flow meter.

****

As a minimum, display the following parameters on the panel:

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

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

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

Level	Indicator	Recorder Point
Boiler drum		X
Bunker or silo	X	

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

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

2.9.5 Panel Piping and Wiring

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

2.9.6 Pilot Lights

Assemble pilot lights 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 finish in baked black enamel. Provide white plastic lens engraved in black ink. Lettering must be 19 mm 3/4 inch high and black. Provide two lamps per pilot and wire independently. Ensure lamps are 6 watts, 24 volts dc, S-6 incandescent type, supplied with color caps, one red and one green per pilot light. Use black lens bezels unless otherwise indicated.

2.9.7 Clock

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

2.9.8 Alarm Annunciator Panel

Provide layout of annunciator panel as shown. Provide panel consisting of a flush-mounted cabinet, mounting trim with clamps, removable rear cover, and alarm modules. Finish cabinet with black baked enamel, aluminum trim, and black alarm bezels. Ensure nameplate size of alarm modules is nominal 70 mm 2-3/4 inches high by 75 mm 3 inches wide in translucent white acrylic plexiglass and engrave all nomenclature on front surface in black lettering. Provide plug-in alarm module that includes epoxy circuit board, one reversible plug-in relay, one general-purpose plug-in relay, relays with dust covers, two selector switches for relay contact selection, and two lamps wired in parallel at 24 volts dc, 6 watts. Mount flasher module and prewire with silence and test pushbuttons. Provide alarm horn of general-purpose construction and mount remotely. Input voltage must be 120 volts ac, 60 cycle. Provide power supply of 120 volts to 24 volts dc output of volt-ampere capacity to suit load. Alarm sequences of panel must provide for "first alert" sequence, with manual reset and ringback sequences. Prewire annunciator panel internally to a rear terminal strip.

2.9.9 Combustion Control Components

Provide components conforming to the requirements of paragraph COMBUSTION CONTROL EQUIPMENT.

2.9.10 Steam and Feedwater Flow Measurement

Provide flow nozzles to measure the steam flow from each boiler and each main steam header outlet. Provide orifice plates to measure feedwater flow to each boiler. Use flange-mounting type nozzles and orifice plates made of stainless steel. Ensure orifice plates are the square edge, concentric, paddle type designed for flange taps. Make minimum straight pipe runs in accordance with AGA XR0603. Provide condensate pots for steam service.

2.9.11 Flue Gas Opacity Monitor

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

2.9.12 Sample Cooler

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

2.9.13 Oxygen Analyzer

If oxygen compensation controls are furnished, provide an oxygen analyzer to indicate, record, and control the percentage of net excess oxygen in, and the average temperature of the flue gas leaving, the boiler. Provide direct probe type oxygen analyzer utilizing an in situ zirconium sensing element. Insert the element directly into the process flue gas stream and directly contact the process gases. Contain sensing element within a protective shield mounted to the ductwork by an adapter plate, furnished by the manufacturer. Equip the analyzer 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. Include any temperature compensation of control required. The output signal range must be 4 to 20 mA dc and must represent 0 to 10 percent as a linear function.

2.9.14 Continuous Blowdown

****

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

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

****

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

2.9.15 Continuous Emissions Monitoring

****

NOTE: A continuous emissions monitoring system (CEMS) is required by the Clean Air Act Amendment (CAAA) of 1990 if the fuel utilized is oil or coal and the heat input is 3 megawatts 10 million BTU/HR or greater. A CEMS may also be required by state or local laws. If a CEMS is necessary the designer will review the CAAA and the relevant state or local law early in the project to allow time to incorporate the required CEMS specification and to determine which flue gas emissions will be included in the required reports. Before acceptance of the installation, furnish 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 to the Contracting Officer. 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. Provide continuous emissions monitoring system (CEMS) equipment as a system by a single manufacturer. Provide a CEMS, meeting the requirements of applicable federal regulations, State of [_____] and local regulations, for each boiler in accordance with manufacturer's recommendations and under the direct supervision of the CEMS equipment manufacturer.

b. Include [sulfur dioxide (SO2)] [oxides of nitrogen (NOx)] [carbon dioxide (CO2)] [particulate matter (PM)] and other information required by federal, state, and local regulations in the reported data. Base SO2 reporting on [analyzer measurement] [fuel flow and percent sulfur calculation] [daily heat input calculation]. Base nitrous oxides, carbon dioxide and particulate matter reporting on analyzers.

c. Include the central processing unit, printer, hard disk drive, and floppy disk drive in CEMS equipment. The floppy disk drive must function as a recorder. TProvide 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 must be via CRT screen.

2.10 WASTE HEAT RECOVERY EQUIPMENT

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

Equip each boiler with [an economizer] [an air preheater]. Units may be separate from or integral with the boiler and complete with insulation and jackets, casings, supports and access doors, and have provision for tube or tube bundle removal and for cleaning. Provide soot blowers as specified in paragraph BOILERS.

2.10.1 Economizers

Provide economizers which are a type normally provided by the boiler manufacturer and that include [finned tubes] [bare tubes] baffles and headers and have provision for cleaning and tube bundle removal. At maximum load, economizer exit water must not be within 17 degrees C 30 degrees F lower than saturation temperature. Provide materials that are capable of withstanding the maximum boiler exit gas temperature plus 28 degrees C 50 degrees F. Provide tubes conforming to ASME BPVC SEC I. The overall design and installation must preclude cold-end corrosion under any load condition. Economizer tube metal temperature must be above the maximum flue gas dewpoint for the fuel being fired under all load conditions.

2.10.2 Air Preheaters

Provide air preheaters which are a type normally provided by the boiler manufacturer and are the recuperative tube plate or regenerative type constructed of materials adequate to withstand the corrosion effects of the flue gases. The overall installation must preclude cold-end corrosion

of the air preheater under any load condition. Ensure temperatures of metals in contact with flue gas are above the flue gas maximum dewpoint temperature for the fuel being fired under all load conditions. Control by steam-preheat or by automatic bypass and integrate with the combustion control system.

2.11 DRAFT FANS

****

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

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

****

Furnish centrifugal fans conforming to AMCA 801 [Type I] [Type II] [forced-draft] [and] [induced-draft] as an integral part of boiler design. Provide centrifugal fans with [backward curved blades] [radial tip blades] [or] [axial flow type]. Size each fan 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 must include margins of 10 percent volume and 21 percent static pressure, plus margins of 5 degrees C 10 degrees F for forced draft fans and 22 degrees C 40 degrees F for induced draft fans. Design induced-draft fans for handling hot flue gas at the maximum boiler outlet temperature adjusted for boiler surface fouling. [Provide induced draft fans with outlet dampers.] Noise levels for fans exceeding 85 decibels at 914.4 mm 3 foot station are not acceptable. Provide [air-cooled] [or] [water-cooled] fan bearings, and backward curved fan blade type with bearings not requiring water cooling may be of the self-aligning antifriction type. [Provide scroll sheets and rotor blades that have liners.]

2.11.1 Draft Fan Control

****

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.

****

Provide forced-draft centrifugal fans with [inlet vane controls] [variable speed control] where indicated. Provide induced-draft centrifugal fans with [inlet vane control] [inlet damper control] [variable speed control]. [Provide axial propeller fans that have variable propeller pitch control.] Provide inlet vanes or dampers suitable for use with combustion control equipment.

2.11.2 Draft Fan Drives

****

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

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

****

Provide fan that is driven by [an electric motor] [or] [a steam turbine]. [Provide [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] electric motor.] [Provide motor starter which is magnetic [across-the-line] [reduced voltage start] type with [general-purpose] [weather-resistant] [watertight] [dust-tight] [explosion-proof] enclosure and furnish with four auxiliary interlock contacts.] [Operate steam turbines properly in a steam pressure range of [_____] Pa psig with steam back pressure of [_____] Pa psig. Ensure turbines have horizontally-split, centerline supported casings, water-cooled bearing housings with ring-oiled, babbitt-lined, bronze packed sleeve bearings. Also equip turbines with a mechanical shaft speed governor and valve, and independent emergency overspeed governor and trip valve, reed tachometer, constant pressure type governor, insulation with removable metal jacket, oil-sight glasses with guards, removable stainless steel steam strainer [without disconnecting piping], any special wrenches and tools required for servicing turbine, and a sentinel warning on the exhaust casings. Provide turbines conforming to NEMA SM 23.]

2.12 AIR DUCTS

Design air ducts connecting the forced-draft fan units with the plenum chamber to convey air with a minimum of pressure loss due to friction. Provide galvanized sheet metal ductwork conforming to ASTM A653/A653M. Make ducts straight and smooth on the inside with laps made in direction of air flow. Brace ducts externally and install and anchor to be free of vibration. Provide access and inspection doors as indicated and required. Construct ducts 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. Make duct joints substantially air-tight and have adequate strength for the service, with 38.1 x 38.1 x 3.2 mm 1-1/2 x 1-1/2 x 1/8 inch structural steel angles used where required for strength or rigidity. Ensure duct walls thickness is as follows:

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

2.13 BREECHING

Construct breeching of no less than 3.416 mm 10 gauge steel sheets conforming to ASTM A36/A36M. Reinforce and brace breeching adequately with structural steel angles no smaller than 50 x 50 x 6.4 mm 2 x 2 x 1/4 inches, and weld all joints and seams in the sheets and angles. Install expansion joints as indicated and as required to suit the installation. Ensure expansion joint are the flexible type requiring no packing. Provide breeching consisting of angle flanges and gaskets for connection to boilers, fans, equipment, or stacks. Ensure breeching connections are gas-tight and are caulked tight all around and sealed with cement to form an air-tight joint. Provide clean-out openings of suitable size at approved locations for access to all sections of the breeching and consisting of tight-fitting, hinged, cast-iron doors with cast-iron frames. Plastic materials polyetherimide (PEI) and polyethersulfone (PES) are forbidden to be used for vent piping for combustion gases.

2.14 STACKS

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

2.15 BLOWOFF TANK

[Construct blowoff tank of 28 MPa 4000 psi reinforced concrete as specified in Section 03 30 00 CAST-IN-PLACE CONCRETE, and fit with a bolted steel manhole cover and frame. Install blowoff pipe, vent pipe, and drain pipe to sewer in pipe sleeves built into the concrete. Fill and caulk the space between the pipe and sleeves with lead wool or similar material to make a water-tight connection. Divide the tank into two sections by a baffle to form a sediment chamber.] [Construct blowoff tank of steel in accordance with NBBI NB-23 PART 1.]

2.16 PUMPS

2.16.1 Boiler Feed Pumps

Size and design boiler feed pumps for the specific application. Furnish pumps having a combined rating of flow and head that results in a wattage horsepower rating less than 185 kW 250 bhp to meet the design requirements of API STD 610. Provide pump that is end-suction, top discharge and support at its centerline. Ensure pump sizes with higher ratings than the above are horizontal-split case, multistage centrifugal pumps. Provide casing construction that is either volute or diffuser design and also support at its casing centerline. All pump ratings must 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 must 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 must not exceed 9000 at the pump's best efficiency point (BEP). The guaranteed NPSH requirements must reflect 3 percent breakdown criteria. The pump's head-capacity (H-Q) curve must be constantly rising to shutoff with no point of inflection. There will be no restriction to operation at any point from minimum continuous flow to design flow.

2.16.1.1 Casings

Pumps must have integrally cast suction and discharge flanges that must be drilled to meet the design pressure of the application. The maximum operating temperature, for design purposes, of any feedpump less than 204 degrees C 400 degrees F is not acceptable. Drill and tap casings. Provide casings with vent and drain connections. Do not require cooling at ratings below 375 kW 500 bhp for pumps designed for this service. This applies to both frame cooling or seal cooling. Below 375 kW 500 bhp, employ antifriction radial and thrust bearings lubricated by flinger rings in a sealed housing. Use mechanical and air-cooled flush piping seals conforming to API STD 610, Plan 23. Above 375 kW 500 bhp, 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. Also provide mechanical seals.. In both cases, ensurestuffing boxes are site-convertible to a packed box. Ensure leakage is no more than 25 mm/hour 25 cc/hr for a seal life of no less than 25,000 hours. Bearing rating must be no less than 100,000 hours (L-10 life) at the point of maximum load, as defined by ABMA 9.

2.16.1.2 Base

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

2.16.1.3 Couplings

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

2.16.1.4 Automatic Recirculation

****

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

****

Furnish all pumps with a self-contained automatic recirculation control valve that is sized for nominally 25 percent of the pump's BEP flow.

2.16.1.5 Turbines

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

2.16.1.6 Electric Motors

Select electric motors for continuous duty and non-overloading characteristics suitable for the power characteristics available. Provide motors that are [splashproof][totally enclosed, nonventilated][totally enclosed, fan-cooled type][totally enclosed, fan-cooled type, suitable for installation in a Class II, Division 1, Group F hazardous location in accordance with the NFPA 70]. [Provide motor starter that is [manual] [[magnetic] [across-the-line] [reduced voltage start]] type with [general-purpose][weather-resistant][water-tight][dust-tight][explosion-proof] enclosure.] Ensure integral size motors are the premium efficiency type in accordance with NEMA MG 1.

2.16.1.7 Shop Hydrostatic Testing

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

2.16.2 Condensate Pumps

****

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

****

Provide horizontal, end suction, single stage, centrifugal, motor-driven condensate pumps with stainless steel shafts and bronze impellers. Provide pumps with stuffing boxes. Lubricate by splash oil with oil level sightglass provided. Subject pumps to the same tests specified for the Boiler Feedpumps.

2.17 CONDENSATE TANK AND ACCESSORIES

2.17.1 Condensate Tank

Design condensate tank for a working pressure of 103 kPa 15 psig and conforming to ASME BPVC SEC VIII D1. Ensure tank has a storage capacity

equal to or greater than indicated and install complete with piping and accessories.

2.17.2 Feedwater Makeup Valve

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

2.18 HEAT EXCHANGERS

Design, fabricate, test, and stamp heat exchangers in accordance with ASME BPVC SEC VIII D1. Additionally, ensure heat exchanger designs meet the requirements of HEI 2623. Closed feedwater heater designs must meet the requirements of HEI 2622. Provide heat exchangers with relief valves as required by ASME BPVC SEC VIII D1 and the HEI Standards. Design heat exchangers using service water to have the service water inside the tubes. Provide exchangers of straight tube designs with bolted full diameter access channel covers to facilitate tube maintenance as required. Return bonnets are acceptable when there are no tubeside nozzle connections at the far end. Provide materials of construction that are all carbon steel, except the service water side which reflects the service water available. When the water quality permits, use stainless steel tubes in accordance with ASTM A249/A249M, Grade TP 304, the remainder of the tube side must be all carbon steel. When the service water is known to contain chloride levels harmful to stainless steels, the tubes must be 90-10 Copper-Nickel in accordance with ASTM B111/B111M Alloy 706; the remainder of the service water side must be as follows: tubesheets, monel-clad steel; channel covers, carbon steel lined with monel; channels and bonnets, monel. Fixed tubesheet designs are preferred when operating conditions do not impose a large differential movement that cannot be readily accommodated with a simple thin-wall metal bellows expansion joint. For larger differentials, a packed floating tubesheet with lantern ring is acceptable up to 1.03 MPa 150 psig design pressure. For pressures above 1.03 MPa 150 psig, use a split ring floating head design. Heat exchangers using steam to heat domestic water or other fluids such as glycol-water mixtures or fuel oil must have the steam in the shell side. Provide exchangers of U-tube designs with bolted full diameter channel covers to facilitate tube maintenance as required. The tubesheet must be the full diameter to match the shell flange and have sufficient threaded bolt holes so that a shell hydro test may be applied without the channel in place. Use materials of construction that are all carbon steel with the exception of the tubes which should typically be specified as stainless steel in accordance with ASTM A688/A688M, Grade TP 304, stress relief annealed temper with the U-bends stress relieved after bending. Fuel oil heaters must have carbon steel tubes in accordance with ASTM A179/A179M and be furnished in the stress relief annealed temper with the U-bends stress relieved after bending. Provide feedwater heaters consisting of all welded construction with bolted full diameter channel covers to facilitate tube maintenance as required. The channel barrel must be integral with the tubesheet and have an internal pass partition bolted cover design that is readily removable when the channel cover is removed. Pass partitions that are sealed with a gasketed groove in the channel cover are prohibited. Ensure materials of construction are all carbon steel except the tubes. Provide pressure boundary material in accordance with ASTM A516/A516M, Grade C, when plate material is required, or ASTM A350/A350M when forging material is required. Provide shroud

plate material for desuperheating and subcooling zones in accordance with ASTM A285/A285M, Grade C. Provide stainless steel tubes in accordance with ASTM A688/A688M, Grade TP 304, stress relief annealed temper with the U-bends stress relieved after bending.

2.19 DEAERATING FEEDWATER HEATER

****

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

****

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

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

2.20 STEAM TRAPS

****

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

a. Inverted Bucket Traps: This type of trap continuously vents air and carbon dioxide at steam temperature and is recommended for modulating loads. The bucket floats on steam to close the outlet and sinks into condensate to open the condensate outlet. Any trapped air is discharged first into the condensate return line and is followed by condensate discharge. This type of trap has the longest life on systems under modulated

control. When large amounts of air are anticipated, an external thermostatic air vent should be installed on a line bypassing the trap to bleed air from the steam line and discharge it to the condensate return line. This system will give optimum performance at low steam pressures with maximum dependability. These traps will handle condensate from fan coil units where condensate must be lifted to return lines located above the equipment. They operate best at near full load conditions where loads do not vary over a wide range. Before operation, traps must be primed by filling them with water.

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

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

d. Thermostatic Traps: These traps are bellows-actuated and contraction of bellows at a few degrees below saturated steam pressure allows condensate air and noncondensable gases to be discharged. As steam reaches the bellows, the expansion of the bellows closes the discharge port. These traps can also be utilized to vent air from a steam system and can be used in conjunction with an inverted bucket type steam trap previously described.

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

f. Any trap selected must be sized for the expected condensate load with an applicable safety factor applied for the particular type of equipment serviced. Manufacturer's application manuals should be consulted to assist in sizing traps. Safety

factors vary from 2:1 to 10:1. An average 3:1 safety factor value will cover most applications.

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

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

****

Provide steam traps in accordance with ASTM F1139, type, style, and class as applicable.

2.20.1 Bucket Traps

Provide either the inverted bucket type or the vertical bucket type bucket traps with automatic air discharge. Design traps for a working pressure of 1.03 MPa 150 psig, but in the correct pressure class to operate properly at the actual steam supply pressure indicated for the system. Construct valve and seat of stainless steel. Construct all other interior parts of corrosion-resistant metal and the traps may be sealed type with corrosion-resistant steel bodies. Ensure traps discharge the condensate to the return line and are connected as indicated. Install a suitable strainer with blow-off valve in the intake connection to each trap. Ensure capacity of traps is no less than that indicated.

2.20.2 Impact-Operated Traps

Impact-operated traps, impulse-operated traps, or thermodynamic traps with continuous discharge may be installed in lieu of bucket traps if applicable, subject to approval of the Contracting Officer.

2.20.3 Thermostatic Traps

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

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

2.20.4 Float and Thermostatic Traps

Design float and thermostatic traps for a steam working pressure of 103 kPa 15 psig which operates with the supply pressure indicated for the system. Base trap capacity on a pressure differential of 15 kPa 2 psi. Provide inlet to each trap with a brass or stainless steel strainer either separately or as an integral part of the trap.

2.21 PRESSURE GAUGES

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

2.22 THERMOMETERS

Provide bimetallic type thermometerswith stainless steel case and stem, separable stem, separable thermowells, and temperature range suitable for the use encountered. Install thermometers in the feedwater heater storage and steam areas, boiler feed pump; in the main condensate return line before entering the surge tank; in the combustion air inlets and outlets of air preheaters, water inlets, and outlets of economizers; in the suction and discharge of boiler feed pumps; in air inlets to forced and induced draft fans; in the flue gas inlets and outlets of economizers and air preheaters; and elsewhere as indicated or specified. Provide thermometers with a universal joint and that are easily read from the operating floor. Ensure thermometers have 127.0 mm 5 inch scales except where 304.8 mm 12 inch scales are required for remote reading and plus or minus 1 percent accuracy.

2.23 WATER METER

****

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

****

Provide water meter, including the three-valve bypass and connections, in

the cold water makeup line [and in each boiler feedwater line]. Provide disk type water meters with reinforced disk for hot water above 65 degrees C 150 degrees F and rubber or synthetic polymer disk for cold water, that are constructed of bronze composition and cast-iron protected by noncorrosive coating. Ensure moving parts subject to wear are easily removable. Provide meters conforming to the requirements of AWWA C700.

2.24 CHEMICAL TREATMENT AND WATER SOFTENING EQUIPMENT

****

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

****

2.24.1 Chemical Feeder

Provide a feeder unit for each boiler. Chemical feeder must be automatic proportioning, shot, or pump type. Provide all appurtenances necessary for satisfactory operation. Base size and capacity of feeder upon local requirements and water analysis. Furnish chemical feed pumps and tanks as a package with the pumps mounted on and piping connected to the tank. Provide pump cylinders, plungers, ball check valves, and check valve bodies consisting of corrosion-resistant materials suitable for the chemicals being pumped. Volumetric accuracy of the pumps must be within one percent over the range indicated. Adjust pump capacities by positioning crank pin with micrometer setscrews. Ensure stroke length scale is divided in percentage graduations engraved on scale. Provide replaceable cylinders for increased or reduced pressure or capacity ranges. Provide drive motors suitable for the electrical power available with drip-proof enclosures. Provide polypropylene tanks and mount on legs. Provide tanks with filling and drain connections and gauge glass. Furnish each tank with one pump, mounted and piped with black iron pipe and fittings, with suction strainer and stainless steel screen, and with 13 mm 1/2 inch relief valve with steel body and stainless steel trim. Provide hinged cover for each tank. Tank bottom must be dished concave to a radius equal to the diameter of the tank. Units must be for phosphate or caustic feed and sulfite feeding. Provide motor-driven agitator. Design the pump to feed the chemical solutions into the boiler feedwater system.

2.24.2 Water Softening Equipment

****

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

****

Provide a [single] [double] unit automatic water softener system as indicated. Design the system for a working pressure of [_____] Pa psig. The system must 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 must be either hot-dipped galvanized after fabrication or polypropylene. Brine piping must be either all copper pipe and fittings

or Schedule 80 PVC. Provide equipment with a total capacity between regenerations of no less than [_____] liters gallons of water of [_____] grams grains hardness when operating at a sustained softening rate of [_____] L/second gpm. Base the system on the data below. Provide test sets for pH comparator for the range [_____] to [_____] sulfite comparator, and phosphate comparator.

2.24.2.1 Water Analysis

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

Constituents*	
Sodium as (Na)	[_____] ppm
Silica as (SiO(2))	[_____] ppm
Calcium as (Ca)	[_____] ppm
Magnesium as (Mg)	[_____] ppm
Iron and aluminum oxides as (Fe(2)O(3)), (Al(2)O(3))	[_____] ppm
Bicarbonates as (HCO(3))	[_____] ppm
Carbonates as (CO(3))	[_____] ppm
Hydroxides as (OH)	[_____] ppm
Sulphates as (SO(4))	[_____] ppm
Chlorides as (Cl)	[_____] ppm
Phosphates as (PO(4))	[_____] ppm
Carbon Dioxide (free CO(2))	[_____] ppm
Total hardness as (CaCO(3))	[_____] ppm
Total solids in solution	[_____] ppm
Volatile and organic matter	[_____] ppm
Suspended matter	[_____] ppm
Free acid	[_____] ppm
Color	[_____]
pH	[_____]
*Numbers in parentheses are subscripts.	

2.24.2.2 Zeolite

Provide the high capacity polystyrene base sulphonic synthetic type zeolite. Provide no less than [_____] cubic meter feet of zeolite with each reactor tank.

2.24.2.3 Reactor Tank

Base reactor tank sizes on allowing a freeboard above the zeolite bed of no less than 50 percent of the zeolite bed depth, and a maximum flow rate of 11.3 mL/square meters per second one gallon/square foot per minute for each 111 mm 4-3/8 inches of zeolite bed depth.

2.24.2.4 Softening System

Provide softening system complete with all piping, control, and power wiring. Install a complete initial charge of rock salt in the brine tank as recommended by the softener manufacturer.

2.24.2.5 Water Test Kit

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

2.24.2.6 Treated Water Storage Tank

Fabricate treated water storage tank from steel plates no less than 4.7625 mm 0.1875 inch thick for shell and heads, and construct in accordance with ASME BPVC SEC VIII D1 for unfired pressure vessels for a design working pressure of 517 kPa 75 psig. Heads must be dished concave to pressure to a radius equal to the diameter of the tank. Provide tank with the connections indicated, an 203.2 mm 8 inch copper ball float, level-operated control valve, valve bypass and accessories, and a protected gauge glass. The tank must be the diameter shown and have a capacity no less than [_____] liters gallons. Hydrostatically test the tank at the factory at no less than 690 kPa 100 psig.

2.25 BUILDING HEATING EQUIPMENT

2.25.1 Unit Heaters

2.25.1.1 General

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

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

Base sound power level data for these units on tests conducted in accordance with ASA S1.13.

2.25.1.2 Propeller Type Unit Heater

Design heater for suspension and arrange for horizontal or vertical discharge of air as indicated. The casings must be no lighter than 0.912 mm 20 gauge steel. Provide suitable stationary or rotating air deflectors to assure proper air and heat penetration at floor level. Suspension from heating pipes will not be permitted. Operate vertical discharge heaters at speeds not in excess of 1200 rpm, except that units with 53 Megajoules 50,000 Btu output capacity or less may operate at speeds up to 1,800 rpm. Provide horizontal discharge unit heaters with discharge or face velocities no greater than the following:

Unit Capacity	Face Velocity
Up to 0.472 cu m/second 1,000 cuf/minute	4.0 m per second800 feet per minute
0.472 to 1.4 cu m/second1.001 to 3,000 cu f/minute	4.6 m per second900 feet per minute
1.4 and over cu m/second3.001 and over cu f/minute	5.1 m per second1,000 feet per minute

2.25.1.3 Cabinet Unit Heaters

Provide centrifugal fan type heaters arranged for floor or ceiling mounting as indicated. House heating elements and fans in steel cabinets with angle iron frames. The cabinets must be of no lighter than 0.912 mm 20 gauge steel. Provide each unit heater fan discharge with an approved adjustment for air diffusion and distribution. Mount the fans on a common shaft with one fan to each air outlet. Equip the fan shaft with self-aligning ball or roller bearings accessible for lubrication. Connect the fan shaft directly to the driving motor or connect indirectly by adjustable V-belt drive rated at 150 percent of motor capacity. Provide guards for all exposed moving parts. Ensure all fans in any one unit heater are the same size.

2.25.1.4 Heating Elements

Heating coils must be copper, and radiating fins may be copper, aluminum, or suitable ferrous alloy. Ensure heating elements are free to expand or contract without developing leaks and are properly pitched for drainage.

Test elements under a hydrostatic pressure of 1.4 MPa 200 psi and submit a certified report of the test to the Contracting Officer.

2.25.1.5 Manual Selection Switches

Provide motors with manual selection switches for [on, off, and automatic] [on-off] operation and equip with thermal-overload protection.

2.25.1.6 Automatic Operation

2.25.1.6.1 Thermostatic Control by Fan Regulation

Control unit heaters automatically by thermostats located where indicated. Provide adjustable thermostats and fit with thermometers. Operate each thermostat on no more than a 2 degrees C 3 degrees F differential over a temperature range of approximately 13 to 24 degrees C 55 to 75 degrees F. The thermostat must start or stop the respective unit heater fan motor when the room temperature falls below or rises above the thermostat set point. Provide summer-winter switches for fan operation adjacent to the thermostat for each unit heater.

2.25.1.6.2 Thermostatic Control by Steam Valve Regulation

Control cabinet type unit heaters automatically by proportioning type thermostats and modulating steam valves located where indicated. Provide on-off switches for fan operation adjacent to the thermostat for each fan unit. The thermostats and valves must maintain the desired room temperature within 1 degree C 2 degrees F of the thermostat set point by regulating the steam supplied to the coil.

2.25.2 Radiator and Convector

Provide each [radiator] [convector] unit with a top supply connection with a control valve and a bottom return connection with a thermostatic trap. Test each unit hydrostatically at the factory and prove tight at a pressure of no less than 690 kPa 100 pounds. Provide extended surface tube-type radiators consisting of suitable metal fins permanently bonded to copper or steel pipe cores threaded at each end for connecting to external piping. Determine radiator capacities in accordance with the HYI-005 Rating Code. Equip radiators with [expanded metal cover grilles fabricated from steel sheets no lighter than 1.519 mm 16 gauge, secured either directly to radiators or to independent brackets] [solid front, slotted, horizontal top grilles fabricated from steel sheets no lighter than 1.214 mm 0.0478 inch thick, secured either directly to radiators or to independent brackets] [solid front, slotted, sloping, top cover grilles fabricated from steel sheets no lighter than 1.214 mm 0.0478 inch thick independently secured to masonry with brackets]. [Test nonferrous convectors hydrostatically at the factory and prove tight under a pressure of no less than 585 kPa 85 psig.]

2.26 AIR COMPRESSOR UNITS

Provide air compressor conforming to ASME PTC 10, except as specified otherwise. Do not exceed 900 rpm compressor speed. Do not exceed 1750 rpm motor speed.

2.26.1 Service Air Compressors

Meet service air requirements as indicated with receivers sized as

indicated. Provide units suitable for heavy-duty service (soot blowing). Provide compressors that are 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 provide with necessary controls, water-cooled aftercooler, moisture separator, drive, receiver, relief valves, and cooling water controls as indicated or required. Provide compressor air intake with a low drop-type air suction filter/silencer suitable for outdoor installation. The aftercooler must 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. Provide moisture separator with an automatic water discharge trap and level gauge. Provide vertical type air receiver, constructed in accordance ASME BPVC SEC VIII D1 for unfired pressure vessels for 1.4 MPa 200 psi working pressure, and equip with flanged inlet and outlet connections, valved drain connection, 152 mm 6 inch dial pressure gauge, pop safety valves, and regulator connections. Cooling water controls for regulating compressor cylinder water temperature and aftercooler water temperature must be thermostatic valve type and install with a three-valve bypass in the water outlet lines ahead of open sight drain funnels. Equip compressor with adjustable, pressure-type unloader controls suitable for continuous compressor operation.

2.26.2 Instrument Air Compressors

****

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.

****

Provide an electric motor-driven oil-free automatic air compressor unit and a refrigerating drying unit. The air compressor must be capable of delivering, at a pressure of [_____] Pa psig, not less than 0.00472 standard cubic meters/second 10 scfm dry air at an atmospheric dew point of -23 degrees C -10 degrees F with entering air at 35 degrees C 95 degrees F, saturated. Size air compressor unit to run no more than 60 percent of the time when all controls are in service. Provide complete air compressor unit 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 must be of vertical construction, in accordance, ASME BPVC SEC VIII D1 with relief valve and drain fittings. Provide a self-contained, refrigerated type air dryer, complete with refrigeration compressor, heat exchanger, automatic controls, and moisture removal trap, or a regenerative desiccant type dryer, as required. Ensure refrigeration unit is the hermetically-sealed type capable of continuous operation at maximum load conditions.

2.27 PIPING

Unless otherwise specified herein, provide pipe and fittings conforming to ASME B31.1.

2.27.1 Pipe

Provide pipe material as specified in TABLE I.

2.27.2 Fittings

Provide pipe fittings as specified in TABLE II.

2.27.3 Nipples

Provide nipples conforming to ASTM A733, Type I or II, as required to match adjacent piping.

2.27.4 Unions

Provide unions conforming to ASME B16.39, type as required to match adjacent piping.

2.27.5 Pipe Threads

Provide pipe threads conforming to ASME B1.20.2MASME B1.20.1, right- or left-hand tapered thread as required.

2.27.6 Expansion Joints

2.27.6.1 Guided, Slip-Tube Type Expansion Joints

****

NOTE: Wherever possible, provision for expansion of steam supply and return pipes will be made by changes in the direction of the run of the pipe or by field-fabricated expansion bends. If expansion joints are not required, applicable paragraphs will be deleted. Where space limitations prevent such provisions for expansion, expansion joints will be installed.

****

Guided, slip-tube expansion joints must conform to EJMA Stds and ASME B31.1. End connections must be flanged. Provide anchor bases or support bases as indicated or required. Design joints for a steam working pressure no less than [_____] Pa psig. Joints must provide for either single or double slip of the connected pipes, as indicated, and for not less than the traverse indicated. [Provide service outlets where indicated or required.]

2.27.6.2 Bellows Type Expansion Joints

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

2.27.6.3 Flexible Ball Type Expansion Joints

Provide flexible ball joints that are [stainless steel] [malleable-iron] [ductile iron] [carbon steel] [bronze] or other alloys as appropriate for the service intended. The joints may be threaded, flanged, or welded end, as required, and must be capable of absorbing the normal operating axial, lateral, or angular movements or combination thereof. Design and

construct ball-type joint in accordance with ASME B31.1 and EJMA Stds, where applicable. Provide flanges conforming to the diameter and drilling provisions of ASME B16.5. Furnish molded gaskets suitable for the service intended.

2.27.7 Valves

Install valves at indicated locations, where specified, and where required for proper functioning and servicing of the system. Valves must be of the pressure class shown. Provide motor-operated valves capable of closing speeds of 2.5 to 5.1 mm/sec 6 to 12 inches/minute. Equip motor operators 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. Ensure motors are suitable for operation on the electrical current characteristics indicated.

2.27.7.1 Check Valves

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

a. Provide valves for 125 pound class steel piping conforming to the following:

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

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

b. Provide valves for 150 pound class steel piping conforming to the following:

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

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

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

2.27.7.2 Gate Valves

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

a. Provide valves for 125 pound class steel piping conforming to the

following:

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

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

b. Provide valves for 150 pound class steel piping conforming to the following:

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

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

c. Valves for system operating pressure greater than 1.4 MPa 200 psi must be split wedge disc type, outside screw and yoke, steel and suitable for specified operating steam pressure, but no less than Class 300 300 pound class. Valves 50 mm 2 inch and smaller must be forged steel with socket welded ends. Valves 65 mm 2-1/2 inches and larger must be steel with butt welded ends.

2.27.7.3 Globe Valves and Angle Valves

Provide globe type valves with outside screw and yoke with bolted bonnets, stainless steel trim, and flat seats, but not the reversed cup type. Provide large and deep stuffing boxes. Install valves with the stem horizontal or above.

a. Provide valves for 125 pound class steel piping conforming to the following:

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

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

b. Provide valves for 150 pound class steel piping conforming to the following:

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

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

c. Valves for system operating pressure greater than 1.4 MPa 200 psi must be suitable for specified operating conditions, but no less than 300 pound class. Valves 50 mm 2 inch and smaller must be forged steel with socket welded ends. Valves 65 mm 2-1/2 inches and larger steel withbutt welded ends. Valves must have renewable flat metal seats.

2.27.7.4 Steam Pressure Reducing Valves

****

NOTE: Single-seated valves should be used when a

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

****

Provide reducing valves designed for the working pressure shown, but not for less than 1.4 MPa 200 psig, wherever indicated or required. Adjust each reducing valve to maintain the desired terminal pressure, regardless of fluctuations in the initial pressure. The valves must be [single seated] [doubled seated], spring-loaded, quiet in operation, and must not stick internally. Provide pilot-operated valves or other controllers using steam or compressed air for operating medium. Valves 65 mm 2-1/2 inches and larger must be cast steel, cast-iron, or semisteel as required for the steam pressure. Valves 50 mm 2 inches and smaller must be bronze. Valve trim for iron body valves must be stainless steel, nickel copper, or other approved corrosion-resisting material. All parts subject to wear must be readily renewable. Provide valves with seats and plugs faced with a cobalt-tungsten carbide mixture, or made of heat-treated stainless steel or a high chromium steel designed to resist erosion. Provide seat and plug facing with a Brinell hardness of no less than 450. Install each valve with a strainer, a three-valve bypass, and a safety relief valve as indicated. Where pressure reducing valves are used for reducing the steam pressure to the deaerating heater, use single seated type valves. Connect sensing lines to the steam space in the deaerator or at least 3 m 10 feet downstream of the pressure reducing valve.

2.27.7.5 Thermostatic Regulating Valves

****

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

****

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

2.27.7.6 Back Pressure Relief Valves

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

2.27.7.7 Boiler Automatic Feedwater Recirculating Control Valve

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

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

2.27.8 Exhaust Heads

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

2.27.9 Strainers

Make strainer body connections the same size as the pipelines in which the connections are installed. Provide strainer bodies consisting of heavy and durable cast steel [or gray cast-iron]. Clearly cast arrows on the sides of bodies to indicate the direction of flow. Equip each strainer with an easily removable cover and sediment basket. The basket must be no less than 0.63 mm 0.025 inch thick corrosion-resistant steel [or sheet brass] with enough small perforations to provide a net free area through the basket of at least 3.30 times that of the diameter of the entering pipe.

2.27.10 Pipe Hangers, Inserts, and Supports

Provide pipe hangers, inserts and supports conforming to MSS SP-58, except as modified herein:

a. Do not use Types 5, 12, and 32.

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

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

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

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

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

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

h. Space horizontal pipe supports as specified in MSS SP-58 and do not install a support over 300 mm 1 foot from the pipe fitting joint at each change in direction of the piping. Do not space pipe supports over 1.5 m 5 feet apart at valves. In the support of multiple pipe runs on a common base member, use a clip or clamp where each pipe crosses the base support member. Spacing of the base support members must not exceed the hanger and support spacing required for any of the individual pipes in the multiple pipe run. Ridgidly connect the clips or clamps to the common base member. Provide a clearance of 3 mm 1/8 inch between the pipe and clip or clamp for all piping which may be subjected to thermal expansion.

i. Supportvertical pipe at each floor, except at slab-on-grade, and at intervals of no more than 4.5 m 15 feet, no more than 2.4 m 8 feet from end of risers, and at vent terminations.

j. Provide Type 35 guides using steel, reinforced polytetrafluoroethylene (PTFE) or graphite slides, where required, to allow longitudinal pipe movement. Provide lateral restraints as required. Provide slide materials suitable for the system operating temperatures, atmospheric conditions, and bearing loads encountered.

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

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

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

l. Support piping in trenches as indicated.

2.28 INSULATION

Provide shop and field applied insulation as specified in Section 23 07 00 THERMAL INSULATION FOR MECHANICAL SYSTEMS.

2.29 TOOLS

Furnish special tools only and include all uncommon tools necessary for the operation and maintenance of boilers, stokers, pumps, fans, controls, meters, special piping systems, and other equipment. Furnish small hand

tools with a suitable cabinet, mount where directed. Also furnish the following tools.

2.29.1 Tube Brush

****
NOTE: Applies to firetube boilers.
****

Provide tube brush, with steel bristles and jointed handle of sufficient length to clean full length of firetubes.

2.29.2 Smoke Pipe Cleaner

Provide cleaner to clean the breeching and smoke connections. Provide cleaner with jointed handle of sufficient length to clean breeching and smoke connections without dismantling.

2.29.3 Firing Tools

Provide firing tools including hoe, poker, and slice bar for each boiler.

2.29.4 Wrenches and Gaskets

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

2.30 COAL HANDLING EQUIPMENT

2.30.1 Screw Conveyor

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

Provide screw conveyor for the lateral distribution of coal consisting of steel screw conveyor with capacity of no less than [_____] cubic meters/second cubic feet/hour when handling coal of the specified maximum lump size. Base maximum capacity of the conveyor on the screws carrying no more than 30 percent of their cross section (except feeder conveyors), and the maximum speed of conveyor must be 60 rpm. Assemble conveyor and housing in sections. Mount sectional flightson steel pipe and connect by coupling shafts. A feeder conveyor may be installed to assume the proper distribution of the load. Mount flights of both the feeder screw and the extended screw on the same pipe. Provide conveyor with sectional supporting hanger bearings of the babbitted type. Do not exceed a conveyor length between bearings of 3.7 m 12 feet. Provide fabricated cast-iron trough ends with feet and fit with babbitted bearings. Locate drive consisting of an electric gear motor and chain driveat the discharge end of the conveyor. Enclosethe chain drive from the motor to the reducer in an oil-tight casing. Thrust in either direction must be absorbed by the thrust bearings. The motor may be mounted on top of the trough. The trough conveyor housing must be no less than 4.8 mm 3/16 inch steel with a 1.897 mm 14 gauge steel, dust-proof cover. Furnish discharge spout and coal gate as indicated. Provide an approved type of supporting saddle.

Space supports at no more than 3 m 10 foot intervals. Motor enclosure must 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 must be [manual] [[magnetic] [across-the-line] [reduced voltage start]] type with [weather-resistant] [dust-tight] [explosion-proof] enclosure.] Provide dust controlling covers and inlet and discharge enclosures for each conveyor.

2.30.2 Belt Conveyor

Belt conveyor must be of the trough type, as shown. Maximum incline of the belt conveyor must not exceed 15 degrees. Provide conveyor support frame with 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. Place decking to protect the return belt from coal sifting and to provide lateral stiffness on top of the stringers. Make idlers accurately to provide a rigid framework that will maintain permanent alignment of well balanced, smooth-running, easy turning idler rolls. All idlers and return rolls must be CEMA Belt Book, Series C5. Provide pressure lubrication to ball or roller bearings. Space 20-degree or 35-degree three-roll type idlers on 1.2 m 4 foot centers, except under loading points and skirts. Spce return idlers on 3 m 10 foot centers. Provide Grade 2 belting as defined in RMA IP-1. The belting must have field-vulcanized splices. Design pulleys in accordance with CEMA B105.1, of heavy welded steel, true to diameter and accurately bored, key seated and tightly fitted to the shafts. Pulley face width for belts 1067 mm 42-inches wide and smaller, that are 150 m 500 feet or more in length, must be belt width plus 100 mm 4 inches; less than 150 m 500 feet in length, must be belt width plus 75 mm 3 inches. Pulley face width for belts 1.2 m 48 inches and larger must be belt width plus 150 mm 6 inches. Provide drive pulleys with 19 mm 3/4 inch thick vulcanized and grooved lagging. Provide snub pulleys with 9.5 mm 3/8 inch vulcanized smooth lagging. Support all conveyor pulley shaft assemblies 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 must 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. Drive conveyor 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 must be [manual] [[magnetic] [across-the-line] [reduced voltage start]] type with [general-purpose] [weather-resistant] [watertight] [dust-tight] [explosion-proof] enclosure.] Provide all belt conveyors with belt misalignment switches, emergency stop pull cords and pull switches, galvanized expanded metal shields over tail pulley, zero speed switches, loading skirts, plugged chute switches, walkways, supports, belt take-ups, belt cleaners, skirt boards, and pulley scrapers. Provide dust controlling covers and inlet and discharge enclosures for each conveyor.

2.30.3 Flight Conveyor

[Scraper] [Shoe-suspended] flight conveyor arranged generally as shown and of the single-strand type must have capacity no less than [_____] metric tons/hour tons/hour when handling coal with approximate weight of 800

kg/cubic meter 50 pcf and with maximum lump size of [_____] mm inches diameter. Base capacity on a maximum speed of 0.508 m/sec 100 fpm with conveyor operating up a [_____] degree incline. Chain must 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 must have protected screw take-up with adjustment of no less than 300 mm 12 inches. Make trough of 4.8 mm 3/16 inch steel plate, minimum. Line all sliding surfaces in contact with the chain or flights with 19 mm 3/4 inch thick, removable, ultra high molecular weight polyethylene liners. Provide both sides of trough with a warning sign "DANGER - DO NOT WELD - FLAMMABLE PLASTIC LINER." Make signs visible on each floor level and at frequent intervals. Provide conveyor with discharge openings as indicated. Provide each with rack-and-pinion-operated gates with handwheels. Motor must drive conveyor through a speed reduction unit which is either direct-connected or roller-chain-connected to the drive shaft. Motor must 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 must be [manual] [[magnetic] [across-the-line] [reduced voltage start]] type with [general-purpose] [weather-resistant] [water-tight] [dust-tight] [explosion-proof] enclosure.] Construct conveyor frame essentially as indicated, with additional bracing as required for rigidity. Provide dust controlling covers and inlet and discharge enclosures for each conveyor.

2.30.4 Bucket Elevators

Furnish dust tight vertical bucket elevators 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 must be [vertical spaced centrifugal discharge] [positive discharge] [continuous bucket type]. The capacity of the elevator must be no less than [_____] metric tons/hour tons/hour when handling coal weighing approximately 800 kg/cubic meter 50 pcf. Linear velocity must be as indicated below:

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

Construct head shaft and foot shaft of cold-rolled steel with the shaft diameters in accordance with manufacturers' standards. Mount both shafts in roller bearings with forced-type lubricating fittings. Foot shaft must have screw take-up with adjustment of no less than 225 mm 9 inches. Install an automatic backstop 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 must be 4.8 mm 3/16 inch thick, minimum. All other flat casing members must be 2.657 mm 12 gauge steel thick, minimum. Provide corner angles and stiffeners to make the elevator self-supporting. In addition, tie the elevator to the adjoining structure at close enough spacing to increase the rigidity of the elevator. Provide boot section with clean-out doors, as well as front

and back removable panels. Provide an inspection door large enough to remove a bucket from either run of the chain in the intermediate section at operating level. Drive elevator by an electric motor installed in a suitable housing at the top of the flight. Motors must 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 must be [manual] [[magnetic] [across-the-line] [reduced voltage start]] type with [general-purpose] [weather resistant] [water-tight] [dust-tight] [explosion-proof] enclosure.] Install a platform adjacent to the motor for servicing the motor and equipment mounted in the hood. Provide access to the platform by an approved type of safety ladder. Locate controls for the operation of the elevator as indicated. Provide dust control covers and inlet and discharge enclosures for each conveyor.

2.30.5 Vibrating Conveyor

Vibrating conveyor must be the electric-motor driven mechanical vibrating type with a capacity of [_____] metric tons/hour tons/hour when handling coal weighing approximately 800 kg/cubic meter 50 pcf and with maximum lump size of [_____] mm inches in diameter. Conveyor must have a conveying length as shown. Fabricate conveyor trough of [_____] mm gauge steel, [_____] mm inches in width and [_____] mm inches deep [and provide with dust-tight cover]. Provide conveyor pans of 9.5 mm 3/8 inch thick, Type 304L solid stainless steel plate. Mount trough on vibrator bars, torsion bars, or coil springs attached to yoker legs of rigid cross brace construction and fabricate of corrosion-resistant material with hardened steel encased rubber bushings at articulation points. Fabricate base of steel channels or angles bolted directly to [building support] [concrete foundations]. The drive must be through an eccentric shaft supported by a double row of self-aligning ball-or roller-bearing pillow blocks. Impart positive action motion to the trough by a cast steel connecting rod attached to the trough by rubber-bushed wristpin and securely locked by taper lock bushings. Drive conveyor 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 must be [manual] [[magnetic] [across-the-line] [reduced voltage start]] type with [general-purpose] [weather-resistant] [water-tight] [dust-tight] [explosion-proof] enclosure.]

2.30.6 Gravimetric Weigh Feeder

The weigh feeder must be a metering belt type device designed to operate at a variable rate ranging from 10 percent of maximum capacity to [_____] metric tons/hour tons/hour. Flow rate must be automatic. Use a silicon-controlled, rectifier dc drive to automatically adjust the belt speed to maintain the rate of material flow, as set on the controller. Provide weigh feeders meeting or exceeding the requirements of NIST HB 44 [Southern] [Eastern] [Western] Weighing and Inspection Bureau. They must have an accuracy of 1/2 of 1 percent of flow rates over their total variable rated capacity. Provide feeder with a flexible boot for connecting the gate to the feeder inlet chute, which in turn must be flared to produce a feed opening tapering from [_____] wide to [_____] wide with the direction of flow of material. Use belts for feeders that meet RMA IP-1 requirements, conforming to the Conveyor and Elevator Belt Handbook, fire-resistant type conforming to the standards of Part 18.65, of the 30 CFR 1. Top belt cover thickness must be 6.4 mm 1/4 inch with

bottom cover 3.2 mm 1/8 inch thick. Belt edges must have minimum 25 mm 1 inch flanges and seal by carrying the cover around the carcass edges during manufacture. Provide cover and skim coat material comparable to those meeting the requirements of the RMA IP-1 for impact and abrasion resistance. The weight sensor must be a heavy-duty, industrial, electronic force transducer flexure-mounted to the force collection system. Provide each sensor with a remote indicating meter and a six-digit totalizing counter located, installed, and connected in the boiler control panel. Use unit frame to provide rigid support for the material load, belt, and idlers. Provide shop assembled unit complete with drive and all appurtenances, which is dust-tight in operation.

2.30.7 Track Hoppers

Provide track hoppers that are standard double hopper design with a belt or vibrating-type feeder as indicated. The hoppers must have a capacity of approximately [_____] metric tons tons and constructed of no less than 9.5 mm 3/8 inch thick, Type 304L stainless steel plates, with slopes no less than 55 degrees, and stiffened with angles. The hoppers may also be of ASTM A36/A36M mild steel, minimum 6.4 mm 1/4 inch thick with replaceable liners 6.4 mm 1/4 inch thick, ASTM A167, Type 304L stainless steel. Use flat head rivets and field bolts inside the hopper. Suspend hopper from the track girders by heavy bolts and cast washers, or carry the sides to the bottom of the track and support by flanges fastened to concrete ledge continuously around the hopper with the concrete forming the top portion of hopper sides. Provide track girders consisting of wide flange beams conforming to the AREMA Eng Man for loading plus impact, complete with bearing plates, WF cross struts, and rail clips. Fit top of hopper with properly sized sections of grating made with steel bars sized [_____] by [_____] mm inches, and cross rods [_____] mm inches in diameter, to form openings [_____] mm inches square.

2.30.7.1 Hopper Gates

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

2.30.7.2 Hopper Feeders

Provide vibrating or belt feeders of manufacturer's standard design for the service required. Motor must 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 must be [manual] [[magnetic] [across-the-line] [reduced voltage start]] type with [weather-resistant] [dust-tight] [explosion-proof] enclosure.]

2.30.8 Truck Hoppers

Provide truck hoppers that are standard double hopper design with a belt or vibrating type feeder as indicated. The hoppers must have a capacity of approximately [_____] metric tons tons and constructed of 9.5 mm 3/8 inch thick Type 304L stainless steel plates, minimum, with slopes of at least 55 degrees, and stiffened with 6.4 mm 1/4 inch angles, minimum. The

hopper may also be of ASTM A36/A36M mild steel, minimum 6.4 mm 1/4 inch thick, with replaceable liners 6.4 mm 1/4 inch thick, ASTM A167, Type 304L stainless steel. Use flat head rivets and field bolts inside the hopper. Support hopper by a flange fastened to the concrete ledge continuously around the hopper, with the concrete forming the top portion of hopper sides. Fit top of hopper with properly sized section of bar grating made with [_____] by [_____] mm inch mild steel bars and [_____] mm inch diameter cross rods to form openings [_____] mm inches square. Provide a supporting beam no less than [_____] mm inches deep, [_____] kg/meter pounds/foot, in a wide flange member, under the grating.

2.30.8.1 Hopper Gates

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

2.30.8.2 Hopper Feeders

Provide vibrating or belt feeders, complete with control of manufacturer's standard design for the service required. Motor must 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 must be [manual] [[magnetic] [across-the-line] [reduced voltage start]] type with [weather-resistant] [dust-tight] [explosion-proof] enclosure.]

2.30.9 Vibrator

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

2.30.10 Car Heaters

****

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.

****

2.30.10.1 Gas-Fired Heaters

Provide infrared radiant type gas-fired heaters located between rails and along the walls of the shed. Heater must have an input of approximately 90 kW 300,000 Btuh. Provide heater with perforated, heavy-gauge stainless steel cover that is not affected by water or coal falling from the car. Provide burner with windproof pilot, main gas solenoid valve, and safety switch to interrupt gas supply to burner if pilot is not burning, and furnish with manual cutoff valves and pressure regulator. Supply heater 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 in compliance with ANSI Z83.19/CSA 2.35 and UL 795.

2.30.10.2 Electric Infrared Radiant Heaters

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

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

Construct coal spouts, chutes, inlet boxes, and outlet hoppers of ASTM A36/A36M steel members no lighter than 3.416 mm 10 gauge, adequately reinforced and braced with angle frames, and with all joints dust tight. Make slopes as steep as possible, but no less than 55 degrees off horizontal. Provide stainless steel or ultra-high molecular weight polyethylene (UHMWP) liners. If UHMWP liners are used, provide each side of chute at each floor level with a warning sign "DANGER DO NOT WELD - FLAMMABLE PLASTIC LINER." Also use impact liners. Provide access openings and inspection openings with cover plates as indicated and required. [Construct silo frames of heavy channel frames the full size of the silo opening and provide with concealed steam pipe and coil around opening.] [Provide outlet hoppers with rack-and-pinion type gates and line with austenitic stainless steel [_____] mm inches thick, conforming to ASTM A167, Type 304L]. Rack-and-pinion gates must be of the type specified for track hoppers.

2.30.12 Car Spotter

Provide electric-motor driven car spotter having a capstan mounted vertically on a rigid housing that completely encloses the gears. Include helical gears and worm gear; fabricate helical gears of high grade steel accurately finished and splash-lubricated, and fabricate worm gear of bronze. Mount all of the mechanism on a steel base rigidly welded to maintain alignment. Couple unit to, and drive by, a separate, [_____] W hp, totally enclosed, nonventilated, hoist-type motor with a full-load speed of 1720 rpm. Use a roller-chain flexible type coupling enclosed in a revolving casing and protect by a heavy steel guard. The unit must have a

starting pull of 22 kN 5000 pounds, a running pull of 11 kN 2500 pounds, and an average rope speed not in excess of 230 mm/sec 45 fpm. Provide unit complete with [_____] m feet of [32 mm 1-1/4 inch diameter manila rope with a breaking strength of 60 kN 13,500 pounds, minimum,] [19 mm 3/4 inch diameter marline-covered standard steel wire rope with a breaking strength of 170 kN 37,600 pounds, minimum,] and a steel car pulling hook with an allowable rope pull of 45 kN 10,000 pounds, so fabricated as to be readily attachable to, and removable from, the car frames.

2.30.13 Coal Bunkers

Construct suspension coal bunkers of size and capacity indicated of ASTM A36/A36M steel plate reinforced and braced as required and install dust-tight. Provide bunkers designed for optimized coal flow, not susceptible to rat-holing or hangups. Provide cylindrical or silo type bunkers to reduce stagnation for each boiler, each with conical discharge hoppers and slopes no less than 70 degrees. Manufacture outlet cone of, or line with, ASTM A167, Type 304 stainless steel. Provide bunkers with rack and pinion type coal shutoff valves, self-cleaning, and dust tight. Valve materials exposed to flowing-coal must be of corrosion resistant steel. Provide an emergency diverter for emptying the bunker.

2.30.14 Coal Storage Silos

2.30.14.1 Silo Design

Silo walls may be slip-formed, cast-in-place reinforced concrete, precast concrete, or other approved construction materials. Concrete must have a 28-day compressive strength in accordance with Section 03 30 00 CAST-IN-PLACE CONCRETE. Silo roof must be reinforced concrete complete with 600 mm 24 inch square, weatherproof, hinged access door. Provide handrail and steel toe-board all around the roof of the silo. Live storage shelf for the silo must be reinforced concrete, sloped no less than 60 degrees from horizontal and supported by steel beams corbelled from the inside walls of the silo. Build live storage outlet hopper to chute and feeders of steel no lighter than 9.5 mm 3/8 inch. Silo reserve storage floor must be reinforced concrete, sloped no less than 60 degrees and laid on well-tamped fill material. Build reclaim outlet hopper to the chute feeding the flight feeder of steel no lighter than 9.5 mm 3/8 inch.

2.30.14.2 Silo Interior Finish

In a concrete stave silo, provide interior finish consisting of a three-coat concrete parget. Apply a brush coat, scratch coat, and a finish trowel coat, one after the other, to produce a smooth monolithic finish. Work parget into the vertical and horizontal grooves to permanently interlock the concrete staves.

2.30.14.3 Silo Exterior Finish

Cover exteriors of stave and concrete silos with a brush coat of gray cement. Apply this coating over all hoops, lugs, and staves to produce a homogeneous finish.

2.30.14.4 Silo Level Controls

Mount a normal high-level and emergency high-level control switch at the top of the silo to shut off the feeding system when the silo is full of coal. Furnish a low-level switch 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. Also furnish switches near the bottom of the silo, as indicated, to signal by light that coal is at a low level in the reserve storage compartment. Provide switches for Class II, Division 1, Group F hazardous location in accordance with NFPA 70.

2.30.15 Coal Crusher

****
NOTE: The designer will select the appropriate type of crusher based on the throughput requirements and an economic analysis.
****

Provide [roll crusher][hammermill][granulator][impactor] coal crusher designed to reduce run-of-mine or lump coal to a maximum lump size of [_____] mm inches. Crusher must have a minimum capacity of [_____] metric tons/hour tons/hour when handling average size bituminous coal. Make housings of heavy castings or welded heavy steel plate. Interior of the housing must have replaceable liners, constructed of abrasion resistant steel. Provide replaceable breaker plate, grates, rolling rings, swing hammers, and other parts of the unit subject to excessive wearing. Crusher must have provisions to trap and reject hard foreign objects without damaging the crusher. Provide shafts consisting of forged, heat-treated alloy steel with bearings mounted in dust-tight housings. Motor must 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 must be [manual][[magnetic][across-the-line][reduced voltage start]] type with [general-purpose][weather-resistant][water-tight] [dust-tight][explosion-proof] enclosure.] Provide premium efficiency type integral size motors in accordance with NEMA MG 1.

2.30.16 Vibrating Feeders

Vibrating feeders must be the [electromagnetic][electromechanical] [single input (Brute Force)] type with a capacity of 0 to [_____] metric tons/hour tons/hour when handling coal weighing approximately 800 kg/cubic meter 50 pcf and with maximum lump size of [_____] mm inches in diameter. Feeder pans and skirts must be replaceable [6.4][9.5][12.7] mm [1/4][3/8][1/2] inch thick, Type 304 solid stainless steel plate without liners. The feeder pan must be fabricated [_____] mm inches in width, [_____] mm inches in length and [_____] mm inches deep. Provide dust control covers of 3.416 mm No. 10 gauge thick steel for each unit. Provide [two][four] rectangular poke holes ([one][two] each side) with 6.4 mm 1/4 inch thick No. 304 stainless steel sliding covers. Make all feeder parts coming in contact with coal of, or line with, Type 304 stainless steel. 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 must not exceed 10 degrees. The vibratory feeders must be [foot][suspension] mounted and completed with supports. Provide suspended feeders with safety cables. Locate feeder drives [above][below] trough. The motors must 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]. Provide premium efficiency type integral size motors in accordance with NEMA MG 1.

2.30.17 Tripper

The tripper must be of steel construction, motor-propelled, automatically reversible, or manually controlled. Equip tripper 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. Do not exceed traversing speed of 127 mm/sec 25 fpm, and include a motor brake. Make chute one way toward the center of the silo and lope at no less than 55 degrees. Provide its seal with all necessary components for installation to suit the bunker/silo slot. Provide plow type seal. Provide tripper with [_____] W hp motor, all reversing and end travel limit switches, cable reel, and 14 No. 12 AWG conductor cable (13 slip rings) and supports for the starter. Mount two pushbutton stations, one on each side of the tripper. Include forward-reverse and tripper stop-run pushbuttons on both stations. Provide conveyor frame including a ladder type cable tray to contain the cable from the reel. Mount reversing switches on the tripper and actuate by track dogs to permit reversal of the tripper over each extreme silo. Mount limit switches on the tripper to operate immediately beyond both extreme limits of tripper reversal. Also furnish a plugged chute switch. Furnish all tripper controls, including limit switches and reversing switches in explosion-proof enclosures approved for Class II, Division 1, Group F service, in accordance with NFPA 70. Also include pulley assemblies, shafts, bearings, carrying and return idlers, tripper framing, and supports.

2.30.18 Trackmobile

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

2.30.19 En-Masse Chain Conveyors

These conveyors must move materials horizontally and/or vertically, with multiple discharge points and in a dust-tight and completely enclosed unit. Conveyors must have a length as shown but not to exceed 75 m 250 feet. Conveyor capacity must be [_____] metric tons/hour tons/hour when handling coal with approximate weight of 800 kg/cubic meter 50 pcf and with maximum lump size of [_____] mm inches diameter. Base maximum capacity on a chain speed not to exceed 813 mm/second 160 fpm. Chain must 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 must be 500-600 BHN. The conveyor casing must be dust tight and of 6.4 mm 1/4 inch thick ASTM A242/A242M high strength, low alloy steel with 3.416 mm No. 10 gauge cover of the same material.

Provide casing with T-1 steel (ASTM A514/A514M Type B) removable liners. The liners must be 19 mm 3/4 inch thick on the bottom and 13 mm 1/2 inch thick on the sides. Provide 19 mm 3/4 inch T-1 steel wear bars for the empty run of the conveyor. Attach liners and wear bars to the casing using countersunk stainless steel bolts with stainless steel nuts and washers. Drive sprocket must be heat treated, induction hardened to a minimum depth of 6.4 mm 1/4 inch. Drive shaft must be heat treated, designed, and sized based on ANSI/AGMA 6113AGMA 6013 requirements. Use spherical double roller bearings. Provide a dust seal where the drive shaft ends go through the casing. Provide 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. Provide each discharge opening with rack-and-pinion-operated gates with [hand wheels][motor operated][air operated]. Motor must drive conveyor through a speed reduction unit which is either direct connected or roller chain connected to the drive shaft. Motor must 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 must be [manual] [[magnetic] [across-the-line] [reduced voltage start]] type with [general-purpose][weather resistant] [water-tight][dust-tight][explosion-proof] enclosure.] Conveyor frame must be constructed essentially as indicated, with support and additional bracing as required for rigidity. Integral size motors must be the premium efficiency type in accordance with NEMA MG 1.

2.31 ASH HANDLING SYSTEM

2.31.1 Boiler Room Ash Handling System

****

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

****

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

2.31.1.1 Ash Hopper

Construct ash removal hopper for each boiler of 6.4 mm 1/4 inch thick steel plate, minimum, with suitable external structural steel supports for connection to boiler ash hopper and necessary internal anchors for holding refractory lining in place. Refractory lining must be 225 mm 9 inches thick on vertical walls and 150 mm 6 inches thick on feed plates. Furnish each hopper with a sliding ash gate. Provide each boiler sliding gate unit with an access compartment to allow gathering and cooling of ash. Provide a cast-iron grate along with a manually-operated air-tight inlet valve for feeding ash into the pneumatic gathering line. Provide a hinged, steel access gate at each compartment. Provide spring loaded air intakes at the end of each header. Base the structural integrity of the hopper on the ash weight of 1120 kg/cubic meter 70 pcf.

2.31.1.2 Clinker Grinder

****
NOTE: Delete this paragraph if coal analysis indicates no possibility of slag formation.
****

Provide clinker grinder unit with [_____] mm inch wide double roll for each hopper outlet gate housing. Provide grinders that have manganese steel rolls and cast-iron housings with grinder shafts mounted on outboard bearings protected by a stuffing box and gland assembly. Pass grinder shafts through stuffing boxes equipped with packing rings and lantern rings for seal water flow. Provide clinker grinder with a reversing mechanism to reverse direction of the grinder rolls should an obstruction stall the grinder. Furnish a 9.5 mm 3/8 inch steel plate ejector feed hopper below each clinker grinder to feed the inlet of the pneumatic ash gathering system. Provide fixed passages in the clinker grinders to prevent discharge of particles too large to be handled by the pneumatic conveying system. Drive each clinker grinder by a totally enclosed type motor and provide with a reversing starter, pressure switch for seal water control, diaphragm-operated seal water valve, and a solenoid valve. Design units for the characteristics of the coal specified that are capable of handling bottom ash at a rate exceeding the conveying system capacity.

2.31.1.3 Conveyor Piping

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

2.31.1.4 Vacuum and Combination Vacuum/Pressure Systems

2.31.1.4.1 Vacuum System

Provide pneumatic suction type ash conveying equipment, complete with vacuum pumps and all component parts necessary for complete and successful operation. Size ash conveying equipment approximately twice the predicted accumulation rate. Provide system with the capacity to convey and empty no less than [_____] metric tons/hour tons/hour of ash weighing approximately [_____] kg/cubic meter pcf. Base tonnage on average handling rate and not on the instantaneous rate.

2.31.1.4.2 Combination Vacuum/Pressure Systems

Provide commercially produced vacuum/pressure equipment for this particular type of service and include a pressure vessel equipped with a filter section at the top and an aeration ring at the bottom. Draw material 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 must 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. Utilize part of the air to clean the filter and pass part of the air through the aeration ring of the vessel to pick up material and convey it under pressure to the storage silo. Furnish unit 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. Control unit operation automatically until switched off at the control cabinet. Skid-mount all automatic valves, interconnecting piping, and the vacuum/pressure vessel. Mount vacuum/pressure pump separately. The control cabinet may be mounted separately or skid-mounted on the vacuum/pressure vessel skid. Capacity of the unit must be approximately [_____] metric tons/hour tons/hour of ash weighing approximately [_____] kg/cubic meter pcf. Design piping sizes for ash collection system to fit the unit supplied. Use vacuum/pressure system where storage silo is more than 150 m 500 feet from the boiler plant. A vacuum system should be used for capacities of less than 45 metric tons/hour 50 tons/hour per system.

2.31.1.4.3 Pump Unit

****

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

****

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

2.31.1.4.4 Control Cabinet

Supply control cabinet for the complete operation of the system and include all running indicating lights as required. Locate a push-button switch conveniently in the boiler house to start and stop the system. Provide a vacuum breaker, operating automatically from a timer, in the bottom ash conveyor line to break the system vacuum.

2.31.1.4.5 Controls

Provide controls for a combination vacuum/pressure system with a selector switch set to automatic position to start the unit in the vacuum cycle. Provide high-level indicator in vacuum/pressure vessel to actuate necessary controls to cut off the vacuum gathering system and pressurize the vessel for pressure discharge of collected material. Provide a

low-pressure switch in the control panel to sense the pressure drop in conveying pressure and to return the unit to vacuum operation. Operate unit continuously in this manner until manually shut down. Set selector switch in manual position to shut the unit down after filling. Then accomplish discharge by pressing the manual discharge button. Provide a high vacuum switch with time delay to shut the system down automatically in the event none of the inlet valves are actuated. Provide heavy-duty switches and controls in accordance with NEMA ICS 1.

2.31.1.4.6 Automatic Air Valve

Provide automatic air valve 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. Provide slide gate as part of the ash system that is manually-operated and interlocked to actuate the automatic air inlet valve.

2.31.1.5 Ash Silo

Provide ash storage silo with a capacity of no less than [_____] metric tons tons of ash and fly ash considered to have an average weight of [_____] kg/cubic meter pcf. Base this capacity on a minimum of 24 hours[60 hours if ash cannot be removed on weekends]. Make silo of welded steel with a cone bottom for truck filling and support on a structural steel tower. Design all elements exposed to the exterior for wind loads of [_____] kg/square meter psf. Provide a 4.3 m 14 foot clearance under the hopper outlet fitting or appurtenance. Provide silo 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. Provide minimum plate thickness of 6.4 mm 1/4 inch. Provide silo 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 must be coal-tar epoxy conforming to SSPC Paint 16.

a. Provide ash storage silo for vacuum system with two stage separators[and a tertiary bag filter]. The primary receiver must be cylindrical and constructed entirely of sectional steel or cast plates suitable for this special service. The receiver must be no less than 900 mm 3 feet in diameter. Locate flanges and bolts on the outside, and direct the impact of ash against heavy iron wear plates of abrasive-resistant alloy. Provide receiver with an air-tight discharge passage no less than 450 mm 18 inches in diameter for free flow of clinkers. Provide means for positive, periodic, and automatic operation in dumping its entire contents into the silo; in addition, design the system so 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 must enter an external secondary separator which must 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] must be no less than 98 percent. Provide secondary separator that is similar to the primary receiver in construction, but may be smaller and of lighter material. Do not extend part of the discharger into the main storage bin. Provide a housing constructed of 6.2 mm 1/4 inch steel plate with a tight-closing access door as an enclosure for the discharger.

b. Mount silo vent filter unit on top of the silo to act as an air

release unit to separate the air from the ash. Drop ash into the silo. Back cleaning of the bag filters must be automatic, utilizing plant air at approximately 690 to 860 kPa 100 to 125 psig. Actuate back cleaning unit whenever the ash handling system is in use. Dust released from the filter bags in the back cleaning operation must fall into the storage silo. Provide housing to allow the unit to operate exposed to the weather in ambient temperatures ranging from minus 40 to plus 55 degrees C minus 40 to plus 130 degrees F.

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

2.31.1.6 Conveyor Type Ash Handling System

****

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

****

Provide funnel shaped ash pits, constructed of 6.2 mm 1/4 inch steel plate, minimum, and covered with a heavy grating with openings approximately 50 mm 2 inches square. Discharge ashes and clinkers from the boiler ash hoppers into ash pits located directly below the ash hopper doors. Arrange a combination drag chain conveyor for horizontal conveying and an elevator conveyor for vertical conveying of ashes, as indicated, to take ashes from the bottom of the ash pits for discharge into the ash silo. Provide conveyors with a capacity of no less than [_____] metric tons/hour tons/hour when handling ashes weighing approximately [_____] kg/cubic meter pcf at a maximum speed of 508 mm/sec 100 fpm. Provide doors for access to all parts, as required. Motor must 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 must be [manual][[magnetic] [across-the-line][reduced voltage start]] type with [general-purpose][weather-resistant][water-tight][dust-tight][explosion-proof] enclosure.]

2.31.1.6.1 Drag Chain Conveyor

Drag chain conveyor must be of a single strand of wide, heat treated, high alloy, drop forged, rivetless drag chain with a [_____] mm inch pitch, [_____] mm inch overall width, and [_____] kg pounds working strength, and a hardness of 460-510 Brinell. Using the upper strand of the chain, convey the ash in a trough constructed of 9.5 mm 3/8 inch cast-iron extending from [_____] mm inches in front of the foot shaft to [_____] mm

inches behind the head shaft and set flush with the floor. Carry the return strand of chain in angle runways set flush with the trench floor. Drive drag chain conveyor by a [_____] mm inch pitch roller chain and [_____] mm inch pitch diameter, [_____] tooth sprocket on the drive shaft, and a [_____] mm inch pitch diameter, [_____] tooth sprocket on the elevator foot shaft.

2.31.1.6.2 Casing

Construct casing of 2.656 mm 12-gauge thick steel, minimum, with 9.5 mm 3/8 inch thick boot plates. Include a gear motor and steel roller chain complete with drive brackets, guards, and backstop in the head end drive. Equip elevator with head-end platform and ladder.

2.31.2 Ash Handling Controls

The ash handling system control panel must contain all necessary instrumentation, including selector switches, annunciators, push buttons, and ammeters required for monitoring and operation of the ash handling system. The panel must graphically display the system. In addition, the panel must contain all necessary timers, relays, and terminal blocks that are required for the control system. Control and monitor the ash removal system from a single panel. Provide panel with push buttons to start automatic operation of each system and also push buttons for individual control of each component. Provide panel with sufficient instrumentation to observe the removal operations and controls to permit effective emergency control. Also provide local control stations at each ash removal point for local manual operation. Provide local selector switches so that equipment may be operated manually for test and maintenance purposes. Control operation of the bottom ash system by a microprocessor-based control system, a solid-state programmable controller or an electromechanical system. All controls and instrumentation for location indoors must have NEMA 12 rating in accordance with NEMA ICS 1. All outdoor components must have NEMA 4 rating, in accordance with NEMA ICS 1. All major equipment components, including control panels and devices, must be factory-mounted, prewired, tubed, and tested to the maximum practical extent. Include controls for fully automatic and sequential operation of the ash handling system. Design these controls so that manual steps, such as continuous monitoring and regulation, will not be required. Incorporate suitable safety interlocks to assure that proper permissive conditions have been met prior to changing the operating status of major system components. Initiate shutdown of the ash handling system, or portion thereof, automatically with alarms, should unsafe conditions arise during operation of the system. Provide facilities for monitoring and control of the ash handling system 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.

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

2.31.3 Submerged Drag Chain Conveyor (SDCC)

Design submerged drag chain conveyor to extract ash at normal capacity [_____] metric tons/hour TPH and maximum capacity [_____] metric tons/hour TPH, based on a dry ash density of approximately [_____] kg/cubic meter pcf. The maximum chain speed must be 76 mm/second 15 fpm. Design SDCC for continuous operation and a storage capacity of [_____] cubic meter cu ft accumulation. The SDCC must have an upper compartment filled with water and a dry lower compartment. Provide equipment to maintain water temperature at approximately 60 degrees C 140 degrees F. The dewatering slope must be at an angle of [_____] degrees with the horizontal. The top trough must be no less than 9.5 mm 3/8 inch thick carbon steel plate, welded construction, lined with renewable abrasion resistant steel wear plates, with a minimum thickness of 13 mm 1/2 inch and 300 BHN. Grind all welds smooth. Provide necessary track guide angles, hold-down angles, and carbon steel chain protectors. The minimum depth of water in the upper trough must be [_____] m feet. Provide dry return chain bottom trough constructed of 9.5 mm 3/8 inch thick steel plate, stiffen and brace with structural shapes and make water-tight. Provide chain track angles with a minimum 13 mm 1/2 inch thick steel replaceable wear flats with a minimum 300 BHN. Also provide wear strips under the return flights, minimum 13 mm 1/2 inch thick and 50 mm 2 inch wide. The conveyor chain must be a double strand round-link or ship-type chain, case hardened, corrosion and abrasion resistant, chrome-nickle-alloy, annealed and carburized with surface hardness between 500-600 BHN. Base design strength and pitch on operating conditions. The conveyor flights must be [_____] mm inches deep by [_____] mm inches thick T-1 steel plates attached on both ends to the chain. Provide flight with top wear pads and bottom wear strips of abrasion resistant steel plate of 300 BHN minimum. Provide a chain tensioner at the tail end of SDCC for maintaining proper tension in both strands of the chain. The assembly must include cast-iron idler wheel, bearings, shaft, guide block and bearing housing. Idler assemblies for both troughs must include heavy duty spherical roller type bearings with external lubrication fittings. The chain drive assembly must include cast-iron wheels with removable, surface hardened, toothed segments, drive shaft, bearings. Drive conveyor 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. Provide speed regulation, self-lubrication, internal cooling, and dynamic braking with this drive. Provide inching capability. Provide hinged inspection doors, windows, and removable panels along the conveyor to permit access and observation at critical points. Provide all inspection doors, windows,

and removable panels in mild steel with stainless steel hardware and must be made completely water-tight. Provide water cooling and drainage connections through flanged connections to the conveyor trough. Make provision 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. Also provide chain cleaning spray.

2.31.4 Dense Phase Ash Handling

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

2.31.5 Fly Ash Collectors

Specify fly ash collectors as specified in Section 44 10 00 AIR POLLUTION CONTROL. Size fly ash collectors to handle total flue gas at maximum boiler load and stack temperature, and provide along with induced draft equipment. Coordinate fly ash collector requirements with boiler draft and control requirements.

PART 3 EXECUTION

3.1 EXAMINATION

After becoming familiar with all details of the work, verify all dimensions in the field, and advise the Contracting Officer of any discrepancy before performing the work.

3.2 EARTHWORK

Perform excavation and backfilling for tanks and piping as specified in Section 31 00 00 EARTHWORK, except conform to the manufacturer's installation instructions for backfilling of fiberglass reinforced fuel tanks.

3.3 EQUIPMENT ERECTION

Install boiler and auxiliary equipment as indicated and in accordance with manufacturers' instructions. Submit detail drawings, consisting of schedules, performance charts, brochures, diagrams, drawings, and instructions necessary for installation of the steam-generating units and associated equipment. Include drawings for piping, pipe anchors, wiring devices, trenches and related foundations, and setting plans certified by the boiler manufacturer and burner manufacturer including coal and ash

handling equipment. Indicate clearances required for maintenance and operation and also contain complete wiring and schematic diagrams, equipment layout and anchorage, and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Include manufacturer's written instructions indicating optimum pressures at all manometer connectors.

3.4 STORAGE TANK INSTALLATION

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

3.5 PIPING INSTALLATION

Cut pipe accurately to measurements established at the jobsite, install without cold springing, and properly clear windows, doors, and other openings. Cutting or other weakening of the building structure to facilitate piping installation will not be permitted. Pipes must be free of burrs, oil, grease, and other foreign matter. Install pipes to permit free expansion and contraction without damaging building structure, pipe, joints, or hangers. Make changes in direction with fittings, except that bending of pipe 100 mm 4 inches and smaller will be permitted provided a pipe bender is used and wide sweep bends are formed. The centerline radius of bends must 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 must conform to ASTM A53/A53M, Grade A, standard, or Grade B extra-heavy weight. Carry vent pipes through the roof as directed and properly flash. Unless otherwise indicated, pitch horizontal supply mains down in the direction of flow, with a grade of no less than 25 mm in 12 m 1 inch in 40 feet. Properly cap or plug open ends of pipelines and equipment during installation to keep dirt or other foreign materials out of the systems. Pipe not otherwise specified must be uncoated. Unless otherwise specified or shown, make connections to equipment with malleable-iron unions for steel pipe 65 mm 2-1/2 inches or less in diameter and with flanges for pipe 80 mm 3 inches or more in diameter. Use brass or bronze unions for copper pipe or tubing. Electrically isolate connections between ferrous piping and copper piping from each other with dielectric couplings or other approved methods. Use reducing fittings for changes in pipe sizes. In horizontal steam lines, use eccentric type reducing fittings to maintain the top of the lines at the same level.

3.5.1 Pipe Sleeves

Provide pipe passing through concrete or masonry walls or concrete floors or roofs with pipe sleeves fitted into place at the time of construction. Install a waterproofing clamping flange as indicated. Do not install sleeves in structural members except where indicated or approved. Provide all rectangular and square openings as detailed. Extend each sleeve through its specified wall, floor, or roof, and cut flush with each surface, except extend sleeves through floors and roofs above the top surface at least 150 mm 6 inches for proper flashing or finishing. Provide membrane clamping rings where membranes are penetrated. Unless otherwise indicated, size sleeves 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 must 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, seal the annular space between pipe and sleeve or between jacket over insulation and sleeve in nonfire rated walls and floors as indicated and specified in Section 07 92 00 JOINT SEALANTS, and seal fire rated walls and floors as indicated and specified in Section 07 84 00 FIRESTOPPING. Provide metal jackets for insulated pipes passing through exterior walls, firewalls, fire partitions, floors, and roofs that are no thinner than 0.15 mm 0.006 inch thick aluminum if corrugated, and 0.41 mm 0.016 inch thick aluminum if smooth, and secure with aluminum or stainless steel bands no less than 9.5 mm 3/8 inch wide and no more than 200 mm 8 inches apart. Where penetrating roofs, before fitting the metal jacket into place, run a 13 mm 1/2 inch wide strip of sealant vertically along the inside of the longitudinal joint of the metal jacket from a point below the backup material to a minimum of 900 mm 36 inches above the roof. If the pipe turns from vertical to horizontal, run the sealant strip to a point just beyond the first elbow. When penetrating waterproofing membrane for floors, extend the metal jacket from a point below the backup material to a minimum distance of 50 mm 2 inches above the flashing. For other areas, extend the metal jacket from a point below the backup material to a point 300 mm 12 inches above floor; or when passing through walls above grade, extend jacket at least 100 mm 4 inches beyond each side of the wall.

3.5.1.1 Pipes Passing Through Waterproofing Membranes

In addition to the pipe sleeves referred to above, provide pipes passing through roof or floor waterproofing membrane with a 1.8 kg 4 poundlead flashing or a 448 g 16 ounce copper flashing, each within an integral skirt or flange. Suitably form flashing, and do not extend the skirt or flange no less than 200 mm 8 inches from the pipe and set over the roof or floor membrane in a troweled coating of bituminous cement. Extend flashing up the pipe a minimum of 250 mm 10 inches above the roof or floor. Seal annular space between the flashing and the bare pipe or between the flashing and the metal-jacket-covered insulation 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. Clamp waterproofing membrane into place and place sealant 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. Provide seals consisting 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. Assemble links loosely 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, tighten the bolts to cause the rubber sealing elements to expand and provide a water-tight seal between the pipe/conduit and the sleeve. Size each seal assembly as recommended by the manufacturer to fit the pipe/conduit and sleeve involved. The Contractor electing to use the modular mechanical type seals must provide sleeves of the proper diameters.

3.5.1.2 Optional Counterflashing

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

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

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

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

3.5.2 Pipe Joints

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

3.5.2.1 Threaded Joints

Make threaded joints with tapered threads properly cut and make perfectly tight with a stiff mixture of graphite and oil, or polytetrafluoroethylene tape or equal, applied to the male threads only, and in no case to the fittings.

3.5.2.2 Welded Joints

Provide fusion welded joints in accordance with ASME B31.1, unless otherwise required. Make changes in direction of piping 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. Forge, flare branch outlet fittings, where used, for improvement flow where attached to the run, reinforced against external strains, and designed to withstand full pipe bursting strength.

3.5.2.2.1 Beveling

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

3.5.2.2.2 Alignment

Align parts to be welded so that no strain is placed on the weld when finally positioned. Align height so that no part of the pipe wall is offset by more than 20 percent of the wall thickness. Flanges and branches must be set true. Preserve this alignment during the welding operation. Provide tack welds of the same quality and make by the same procedure as the completed weld; otherwise, remove tack welds during the final welding operation.

3.5.2.2.3 Erection

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

3.5.2.2.4 Defective Welding

Remove and replace defective welds. Repair defective welds in accordance with ASME B31.1.

3.5.2.2.5 Electrodes

After filler metal has been removed from its original package, protect or store it so that its characteristics or welding properties are not affected. Do not use electrodes that have been wetted or that have lost any of their coating.

3.5.2.3 Flanges and Unions

Flanges and unions must be faced true and made square and tight. Provide gaskets consisting of nonasbestos compressed material in accordance with ASME B16.21, 1.6 mm 1/16 inch thickness, full face or self-centering flat ring type. Ensure gaskets contain aramid fibers bonded with styrene butadiene rubber (SBR) or nitrile butadiene rubber (NBR). Use NBR binder for hydrocarbon service. Provide union or flange joints in each line immediately preceding the connection to each piece of equipment or material requiring maintenance, such as coils, pumps, control valves, and other similar items.

3.5.3 Supports

3.5.3.1 General

****

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 must have the excess hanger loads suspended from panel points.

****

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

3.5.3.2 Seismic Requirements

****

NOTE: Provide seismic requirements if a Government

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

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

3.5.3.3 Structural Attachments

Provide structural steel brackets required to support piping, headers, and equipment, but not shown, as specified under this section. Provide material used for supports as specified under Section 05 12 00 STRUCTURAL STEEL.

3.5.4 Anchors

Provide anchors wherever necessary or indicated to localize expansion or prevent undue strain on piping. Provide anchors consisting of heavy steel collars with lugs and bolts for clamping and attaching anchor braces, unless otherwise indicated. Install anchor braces in the most effective manner to secure the desired results, using turnbuckles where required. Do not attach supports, anchors, or stays where they will injure the structure or adjacent construction during installation or by the weight of expansion of the pipeline.

3.5.5 Pipe Expansion

3.5.5.1 Expansion Loops

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

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

3.5.5.2 Expansion Joints

****
NOTE: If expansion joints are not required, this paragraphs will be deleted. Where space limitations prevent such provisions for expansion, expansion

joints will be installed, and blanks will be filled as appropriate.
****

Use expansion joints to provide for either single or double slip of the connected pipes, as required and indicated. Make initial setting in accordance with the manufacturer's recommendations to allow for ambient temperature at time of installation. Install pipe alignment guides as recommended by the joint manufacturer, but in any case no more than 1.5 m 5 feet from expansion joint, except in lines 100 mm 4 inches or smaller install guides no more than 600 mm 2 feet from the joint.

3.5.6 Valves

Install gate or globe valves with stems horizontal or upright. Install swing check valves in horizontal piping with the cap or bonnet up, or in vertical piping with the flow upward. Install lift or piston check valves in horizontal piping with the cap or bonnet up.

3.6 BURIED PIPING INSTALLATION

3.6.1 Protective Coating for Underground Steel Pipe

Give all steel pipe installed underground 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 must have the protective covering applied by hand, preferably at the plant, applying the covering to the pipe. Do not field apply coatings until the piping has satisfactorily passed the leak or hydrostatic test. Coat and wrap all field joints by hand. Perform all hand coating and wrapping in a manner and with materials that will produce a covering equal in effectiveness to that of the mechanically-applied covering.

3.6.2 Cleaning of Surfaces to be Coated

Solvent-wash steel surfaces to assure an oil-and-grease-free surface and blast-cleaned to bare metal as specified in SSPC SP 6/NACE No.3. Clean areas that cannot be cleaned by blasting to bare metal by powered wire brushing or other mechanical means. Ensure air supply for blasting is free from oil and moisture. Following cleaning, wipe surfaces with coal-tar solvent naphtha and allow to dry. The surfaces to be coated must be free of all mill scale and foreign matter such as rust, dirt, grease, oil, and other deleterious substances. Coat surfaces as soon as practicable after the cleaning operation.

3.6.3 Coating Materials

Coat buried steel piping with one of the following methods:

3.6.3.1 Bituminous Pipe Coating

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

Provide bituminous protective system that is a coal-tar enamel and primer coating system, consisting of a coal-tar priming coat, a coal-tar enamel coat, a wrapper of coal tar saturated felt, and a wrapper of kraft paper, or a coat of water-resistant whitewash, applied in the order named and conforming to the requirements of AWWA C203 in all respects as to materials, methods of application, tests, and handling, except do not apply an interior lining.[In addition, where excessively corrosive soils are encountered, give the piping a second coating of coal-tar enamel and a second wrapper of felt.] Coat and wrap joints and fittings.

3.6.3.2 Polyethylene Pipe Coating

Continuous extruded polyethylene coating and adhesive undercoat application procedure, including surface preparation, must be a factory-applied system conforming to NACE SP0185, Type A. Tape-wrap joints, valves, flanges, and other irregular surfaces as outlined under the tape-wrapping system, except apply the tape half-lapped, and prime all extruded polyethylene coating and adhesive undercoat surfaces to be tape-wrapped with a compatible primer before application of tape. Use primer as recommended by the tape manufacturer and approved by the applicator of the extruded polyethylene coating. Repair damaged areas of extruded polyethylene coating by tape-wrapping as described under the tape-wrapping system, except press any residual material from the extruded polyethylene coating into the break or trim off. Prime all areas to be taped and apply the tape half-lapped.

3.6.3.3 Tape-Wrap Pipe Coating

Prime cleaned surfaces before applying tape as recommended by the manufacturer of the tape. Provide tape which is an approved, pressure-sensitive, organic plastic tape with a minimum nominal thickness of 0.51 mm 0.020 inch. The tape must conform to ASTM G21 for fungus resistance. Apply tape to clean, dry, grease-free, and dust-free surfaces only. Weld beads must be wire-brushed. Remove all burrs and weld spatter. Cover weld beads with one wrap of tape before spiral wrapping. At each end of straight runs, apply a double wrap of one full width of tape at right angles to the axis of the spiral wrapping. Remove kraft paper protective wrapping, if any, from the pipe before the tape is applied. For material which is wrapped before it is placed in its final position, protect the wrapping at sling points with roofing felt or other approved heavy shielding material, or handle with canvas slings. Repair damaged wrapping as specified. Wrap pipe in straight runs spirally, half-lapping the tape as it is applied. For pipe smaller than 100 mm 4 inches, use one layer half-lapped. For pipe 100 mm 4 inches and larger, use two layers half-lapped with the second layer wrapped opposite-hand to the first. Wrap joints, coupling fittings, and similar units, and damaged areas of wrapping, 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, apply one layer half-lapped and stretched sufficiently to conform to the surface, followed by a second layer half-lapped and applied with tension as it comes off the roll.

3.6.3.4 Epoxy Coating System

Provide epoxy coating system conforming to AWWA C213, Type II. Fittings, valves, and joints must be factory coated with materials identical to those used on the pipe, or may be field coated with a two-part epoxy system recommended by the manufacturer of the pipe coating system. Field

protection may also be provided for joints and fittings with a coal tar tape hot-applied over a compatible primer.

3.6.3.5 Coating Inspection and Testing

After field coating of the pipe joints, inspect the entire pipe 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. Equip holiday detector with a bell, buzzer, or other audible signal which operates when a holiday is detected. Repair all detected holidays in the protective covering. Occasional checks of holiday detector potential will be made by the Contracting Officer to determine suitability of the detector. Perform inspection for holidays just before covering the pipe with backfill and take every precaution during backfill to prevent damage to the protective covering. Furnish equipment and labor necessary for inspection.

3.6.4 Installing Buried Piping

Handle pipe and accessories carefully to assure a sound, undamaged condition. Take care not to damage coating when lowering pipe into a trench and when backfilling. Install nonmetallic pipe in accordance with pipe manufacturer's instructions. Lay underground pipelines with a minimum pitch of 25 mm per 15 m 1 inch per 50 feet. Horizontal sections must have a minimum coverage of 450 mm 18 inches. Piping must be free of traps and drain toward tank. Rest full length of each section of underground pipe solidly on the pipe bed. Make piping connections to equipment as indicated, or as required, by the equipment manufacturer. Make tank connections with two elbow swing joints [or flexible connectors] to allow for differential settlement. Clean interior of the pipe thoroughly of all foreign matter before being lowered into the trench and keep clean during installation. Do not lay pipe in water or when the trench or weather conditions are unsuitable. When work is not in progress, securely close open ends of pipe and fittings so that water, earth, or other substances cannot enter the pipe or fittings. Replace any pipe, fittings, or appurtenances found defective after installation. Make threaded joints with tapered threads and make perfectly tight with joint compound applied to the male threads only. This requirement does not apply for the gauging hatch or similar connections directly over the tank where the line terminates in a fitting within a cast-iron manhole designed to allow for differential setting. Where steel piping is to be anchored, weld the pipe to the structural steel member of the anchor and patch the abraded area with protective coating or covering as specified. Fit piping passing through concrete or masonry construction with sleeves. Make each sleeve sufficient length to pass through the entire thickness of the associated structural member and large enough to provide a minimum clear distance of 13 mm 1/2 inch between the pipe and sleeve, except where otherwise indicated. Sleeves through concrete may be 0.912 mm 20 gauge metal, fiber, or other approved material. Locate sleeves accurately on center with the piping and fasten securely in place. Caulk and fill space between the sleeves and the pipe with bituminous plastic cement or mechanical caulking units designed for such use.

3.6.5 Fiberglass Reinforced Plastic (FRP) Pipe

Field assemble pipe in conformance with the manufacturer's written instructions and installation procedures. Several pipe joints having interference-fit type couplings may be field-bonded and cured simultaneously. However, do not move pipe nor make additional joints

until the previously laid joints are completely cured. Fit joints not having interference-fit type couplings with a clamp which holds the joint rigidly in place until the joint cement has completely cured. The clamps must have a protective material on the inner surface to prevent damage to the plastic pipe when the clamp is tightened in place. Provide pipe with a device or method to determine when the joint is pulled against the pipe stop. Use a gauge provided by the pipe manufacturer to measure the diameter of the spigot ends to insure the diameter conforms to the tolerances specified by the manufacturer. Gauge all pipe ends. Utilize FRP pipe for buried piping only. No aboveground FRP pipe is allowed. Cut with a hacksaw or circular saw with an abrasive cutting wheel.

3.6.5.1 Installation

Bury pipe to the elevation shown on the profiles, except do not bury pipe under roadways less than 900 mm 36 inches. Backfill must not include large or sharp-edged rocks of any size in direct contact with the pipe surfaces. Compact to avoid damage to the pipeline. Provide conduits or sleeves of steel pipe at least 50 mm 2 inches in diameter larger than the FRP pipe size under heavy traffic roadways. Limit bending of pipe to follow ditch contours to long trench curvatures and do not permit for abrupt changes in pipe direction. Bend radii must not be less than shown in the manufacturer's installation procedures.

3.6.5.2 Thrust Blocks

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

3.6.5.3 Curing of Field-Bonded Joints

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

3.6.5.4 Metal to FRP Connections

Make metal to FRP connections with flanged connections. Use flat-faced steel flanges for bolting to FRP flanges. Where raised-face steel flanges are used, utilize spacer rings to provide a flat-face seat for FRP flanges. Use a full-face Buna-N gasket, 3.2 mm 1/8 inch thick with a shore hardness of 50 to 60, between all flanged connections. The FRP flange must have raised sealing rings. Use flat washers under all nuts and bolts on FRP flanges. Provide bolts and nuts consisting of noncorrosive metal and torque to no more than 135 newton meters 100 ft-lbs. Do not bury flanges. Provide a concrete pit for all flanged connections.

3.6.6 Buried Fuel Piping

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

3.7 CATHODIC PROTECTION

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

3.8 FIELD PAINTING

****

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

****

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

3.9 CLEANING OF BOILERS AND PIPING FOR TESTING

3.9.1 Boiler Cleaning

After the hydrostatic tests but before the operating tests, clean boilers of foreign materials. Wherever possible, wire-brush surfaces in contact with water 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. Fill boilers with a solution consisting of the following proportional ingredients for every 3785 liters 1000 gallons of water and operated at approximately 207 to 350 kPa 30 to 50 psig for a period of 24 to 48 hours, exhausting steam to the atmosphere:

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

Thoroughly dissolve hemicals in the above proportions or as otherwise approved in the water before placing in the boilers. After the specified boiling period, allow the boilers to cool and then drain and thoroughly flush. Clean piping by operating the boilers for a period of approximately 48 hours, wasting the condensate.

3.9.2 Boiler Water Conditioning

Provide boiler water conditioning including chemical treatment and blowdown during periods of boiler operation to prevent scale and corrosion in boilers and in supply and return distribution systems from the initial startup of the system, through the testing period, and to final acceptance of the completed work but for at least 30 days of operation. Use approved chemicals and method of treatment.

TABLE I. PIPE				
Service	Pressure, kPa psig	Material	Specification	Type
Steam	0-35000-500	Std. wt. black steel	ASTM A53/A53M	Type E, Grade A
Condensate return	0-17000-250	Extra strong black steel	ASTM A53/A53M	Type E, Grade A
		Copper pipe	ASTM B42	[_____]
Boiler feed & blowoff lines	0-41000-600	Extra strong black steel (2)	ASTM A53/A53M	Type E, Grade A
Feedwater piping	0-8600-125	Std weight black steel	ASTM A53/A53M	Type E, Grade A
Water column (1)	0-41000-600	Std weight black steel (2)	ASTM A53/A53M	Type E, Grade A
Vent & exhaust pipe	0-1700-25	Std weight black steel	ASTM A53/A53M	Type E, Grade A
Compressed air	0-8600-125	Std weight black steel	ASTM A53/A53M	Type E, Grade A
Gauge piping	0-1700-25	Copper tubing	ASTM B88MASTM B88	Type K or L
		Blask steel (2)	ASTM A53/A53M	Type E, Grade A
Fuel oil (No. 2)	0-10000-150	Copper tubing	ASTM B88MASTM B88	Type K or L
		Fiber reinforced plastic (FRP) (buried service only)	API Spec 15LR	[_____]
Fuel oil (Nos. 4, 5 & 6)	0-10000-150	Std weight black steel	ASTM A53/A53M	Type E, Grade A
Control air	0-10000-150	Copper tubing	ASTM B68/B68M	[_____]
		Std weight black steel	ASTM A53/A53M	Type E, Grade A
Note 1: No bending of pipe will be permitted. Provide crosses with pipe plugs at connections.				
Note 2: Extra strong (XS) minimum weight. Conform to ASME B31.1 for wall thickness.				

TABLE II. FITTINGS				
Service	Size, mm inches	Title	Materials	Specification
Steam (1)	Under 80 mm 3 inches	Threaded	Malleable-iron	ASME B16.3
	Under 80 mm 3 inches	Threaded	Steel	ASME B16.11
	80 mm 3 inches and larger	Flanged	Steel	ASME B16.5
	80 mm or larger	Buttwelded	Steel	ASME B16.9
Condensate return	Under 80 mm 3 inches	Threaded	Cast-iron	ASME B16.4 Black, Class 250
	Under 80 mm 3 inches	Threaded	Malleable-iron	ASME B16.3, Class 300
	Under 80 mm 3 inches	Threaded	Bronze	ASME B16.15
	80 mm 3 inches and larger	Buttwelded	Steel	ASME B16.9
Vent pipe	Under 80 mm 3 inches	Threaded	Malleable-iron	ASME B16.3
	80 mm or larger	Buttwelded	Steel	ASME B16.9
Exhaust pipe	Under 80 mm 3 inches	Threaded	Zinc-coated malleable-iron	ASME B16.3
	80 mm 3 inches and larger	Buttwelded	Steel	ASME B16.9
Boiler feed (2)	Under 80 mm 3 inches	Threaded	Malleable-iron	ASME B16.3
	80 mm 3 inches and larger	Buttwelded	Steel	ASME B16.9
Feedwater pipe	Under 80 mm 3 inches	Threaded	Malleable-iron	ASME B16.3
	80 mm 3 inches and larger	Buttwelded	Steel	ASME B16.9
Blowoff lines (2)	All	Buttwelded	Steel	ASME B16.9
		Socket welded	Steel	ASME B16.11
		Flanged with long radius elbows	Steel	ASME B16.5
Water column piping (2)	Under 80 mm 3 inches	Threaded	Malleable-iron	ASME B16.3
Fuel oil	All	Threaded	Malleable-iron	ASME B16.3
		Flared or brazed	Cast or wrought bronze	ASME B16.18 ASME B16.26
		Plastic	FRP	Compatible with pipe API Spec 15LR

TABLE II. FITTINGS				
Service	Size, mm inches	Title	Materials	Specification
Gauge pipe	All	Flared or soldered	Cast or wrought bronze	ASME B16.18 ASME B16.26
Note 1: Conform to ASME B31.1 for wall thickness. Match requirements for steam piping.				
Note 2: Conform to ASME B31.1 for wall thickness, except minimum must be extra strong pipe. Match piping requirements.				

3.10 MANUFACTURERS' FIELD SERVICES

Provide the services of a manufacturer's representative who is experienced in the installation, adjustment, and operation of the equipment specified. Supervise the installing, adjusting, and testing of the equipment.

3.11 FIELD TRAINING

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

3.12 FRAMED INSTRUCTIONS

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

3.13 TESTS

****

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

References to inapplicable types of boilers will be deleted.

****

Submit test reports in booklet form showing all field tests performed to adjust each component and all field tests performed to prove compliance with the specified performance criteria, upon completion and testing of the installed system. Indicate the final position of controls in each test report. Submit a written statement from the manufacturer's

representative certifying that combustion control equipment has been properly installed and is in proper operating condition, upon completion of the installation. The action settings for all automatic controls in the form of a typed, tabulated list indicating the type of control, location, setting, and function.

3.13.1 Hydrostatic Tests

Following erection, test each boiler hydrostatically and prove tight under a gauge pressure of 1-1/2 times the working pressure specified. Following the installation of piping and boiler house equipment, but before the application of any insulation, make hydrostatic tests and the prove system tight under gauge pressures of 1-1/2 times the specified working pressure. Test the boilers and inspect the piping connections by a NBBI-commissioned boiler inspector for determining compliance with all requirements in ASME BPVC SEC VIII D1 and supply the Contracting Officer with a certificate of approval for each boiler. After flushing and operationally testing, leak test underground portions of oil containing piping systems. The test must be the [standpipe method][buoyancy device] type and conform to the requirements in NFPA 329. Do not involve pressurization of the system in any way which could increase the rate of product escape through an established leak in the test method.

3.13.2 Efficiency and Operating Tests

Upon completion of installation, subject the boiler plant to operating tests required to demonstrate satisfactory functional operation. Adjust equipment and controls before the scheduled operating test. Submit a testing schedule to the Contracting Officer at least 15 days before the scheduled test. Conduct each operating test as directed by Contracting Officer.

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

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

	Percent of Capacity	
Time (Minimum)	Waterwall and Watertube Boilers	Firetube and Boilers
First 1 hour	50	50
Next 1 hour	75	75
Next 4 hours*	100	100

	Percent of Capacity	
Time (Minimum)	Waterwall and Watertube Boilers	Firetube and Boilers
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 must be not less than specified. Maximum moisture content of saturated steam leaving the boiler must be as specified.		

c. Conduct efficiency and general performance tests on the boilers by a qualified test engineer, and observed by the Contracting Officer. Set up all testing apparatus, calibrate, test, and be ready for testing the boiler before the arrival of the Contracting Officer.

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

e. Include all pertinent data tabulated in the ASME PTC 4 abbreviated efficiency test. Provide necessary temporary test piping no less than 100 mm 4 inches in diameter and steam silencer to exhaust excess steam to atmosphere in the event the boiler load is insufficient to meet the capacity specified. Provide control valve for exhausting excess steam to atmosphere in a convenient location inside the boiler room. Instruments required for conducting the boiler tests are contained in ASME PTC 19.11.

3.13.3 Test of Fuel Burning Equipment

Test of fuel burning equipment must demonstrate that equipment installed will meet the requirements of the specifications. Oil burners must meet the test requirements of UL 296. Demonstrate accuracy range and smoothness of operation of the combustion controls 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 must be as specified. Verify specified turndown ratio by firing at the minimum firing rate. Verify operation of the flame safeguard control by simulated flame and ignition failures.

3.13.4 Test of Deaerating Feedwater Heater

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

3.13.5 Test of Water Treatment Equipment

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

3.13.6 Test for Steam Purity and Water Level Stability

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

[3.13.6.1 Conductivity Tests for Boilers without Superheaters

****
NOTE: Delete the inapplicable paragraph.
****

Make steam tests for boilers without superheaters, not used for power generation or large turbine drive, on steam sampled in accordance with ASTM D1066. Do not exceed 30 microhms at 18 degrees C65 degrees F conductivity of the steam corrected for carbon dioxide and ammonia content.

]3.13.6.2 Conductivity Test, Boilers with or without Superheaters

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

3.13.6.3 Water Level Stability Test

[Conduct water level stability test first by use of the manual bypass around the feedwater regulator. Then repeat test using the automatic feedwater regulator. Boiler must maintain specified water level stability under both conditions.]

-- End of Section --